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RICE PRICE FLUCTUATION AND AN APPROACH TO PRICE STABILIZATION IN BANGLADESH

Raisuddin Ahmed
Andrew Bernard

February 1989

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FOREWORD

Correction of the distorted structure of relative prices and prevention of wide fluctuations in the level of commodity prices constitute twin challenges in agricultural price policies. While macroeconomic instruments are commonly used in changing relative prices, the task of price stabilization requires comprehensive sectoral analysis of price relations, stock requirements, market integration, and various other factors that destabilize supply and demand.

IFPRI's initial analyses of price stabilization were limited to the issue of optimal stock of foodgrains. Thomas Pinckney's work on stock policies in Kenya and Pakistan and Raj Krishna and Ajay Chhibber's research on India have demonstrated how optimal stock policies can save scarce public resources so urgently required for economic development.

This research report by Raisuddin Ahmed and Andrew Bernard focuses less on optimal stock and more on a consistent framework and operational rules for stabilization of prices. It examines the factors that cause fluctuation in prices and develops a framework for containing annual and seasonal variation of prices within a bound. Although the research is conducted in the context of Bangladesh, the approach is applicable to other countries. IFPRI is currently involved in extending this research by applying it in Bangladesh through a collaborative arrangement with the Bangladesh Ministry of Food. Such a link between research and application will bring IFPRI's research directly to bear on the policy needs of developing countries, improving both current policy and future research.

John W. Mellor

Washington, D.C.
February 1989

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This study was initiated to examine fluctuations in rice prices of Bangladesh, where policymakers have regularly experienced frustration with the management of prices of this critical commodity. The repeated shifts from a position where they fought to contain upward price movement to another where they confronted the task of stemming the downward dash of prices have puzzled them. The absorbing nature of the task has diverted attention from issues and problems of long-run development.

Our deepest gratitude goes to all those public officials in Bangladesh who shared their experiences and understanding in unfolding the problems of price stabilization in Bangladesh. It is hoped that the study will help solve the puzzle and provide a basis for removing the frustrations.

The final version of the study reflects the assistance of many who provided access to data, commented on earlier drafts, and extended guidance in the analytics of complicated measurement. While we express our general appreciation to all those involved in such assistance, particular recognition of extremely useful help goes to Romeo Bautista, John W. Mellor, Robert Nevin (USAID, Dhaka), Mahabub Hossain (BIDS, Dhaka), R. R. Piggot (Australia), Stephen Vosti, Mustapha Rechache, and a number of anonymous reviewers.

Raisuddin Ahmed
Andrew Bernard

SUMMARY

Traditional welfare economists often conclude that commodity price stabilization schemes are economically wasteful. Nevertheless, most contemporary developing countries use some type of stabilization policy to address price instability arising from shocks in the domestic supply of foodgrains. They do so because the assumption that consumers can save enough in times of low prices to pay for higher prices later on is unrealistic in economies with widespread poverty and imperfect capital markets. The positive and comprehensive dimensions of stable prices are considered in this report.

This report examines the sources and extent of rice price variability in Bangladesh and provides a complete framework for the implementation of a simple yet effective mechanism for limiting that variability in the future. Although the framework is developed in the context of Bangladesh, the general approach should be applicable for most developing countries.

Annual price fluctuations in the postindependence or posttechnology period in Bangladesh have increased, and supply and demand forces in the rice market no longer move together to stabilize prices. In addition, imports that are controlled by the government have taken on a new, more important role in helping to stabilize prices. These developments will significantly affect the actual implementation of a price-targeted program in Bangladesh. If, as is indicated, supply shocks are becoming more important than demand shifts as a source of price variability, then government action on the supply side has to diminish rather than augment price variability. To do this, a timely mechanism to respond to any dramatic shortfall in production (for example, crop loss from natural calamity) should be developed and put into action. The coordination of imports with a national stocking policy is a critical element in any rice price program in Bangladesh. Imports can provide long-term access to sufficient amounts of foodgrains, whereas the stocks on hand offer shorter-term and location-specific responses to foodgrain deficits.

While the structure of the overall economy of Bangladesh has been changing, so too has the rice market itself undergone dramatic shifts in recent years. New high-yielding varieties of rice have increased overall production and have changed the intrayear pattern of production and prices. Where once the aman crop dominated the annual production of rice, now the large boro and aus crops, especially the high-yielding varieties, cause prices to fall back almost to their December (aman) levels. This new pattern of seasonality has implications for the government's role in the procurement and distribution of foodgrains. A second procurement season in the regions growing rice in the boro and aus seasons is likely to be required if a price-based program of stabilization is adopted.

Although most of this study focuses on temporal aspects of prices in the rice market, spatial relationships should not be overlooked. The analysis of market integration shows that, although transmission of prices does occur to some degree in all markets at certain times in specific locations, the integration of markets is not complete. This implies that particular attention should be paid to those markets that are not well linked to the overall rice economy, and procurement and sales procedures should be adjusted accordingly. Special attention should be given to the districts of Patuakhali, Barisal,

Dinajpur, Rajshahi, and Rangpur in procuring the aman crop. Similarly, Chittagong, Kushtia, and Jessore should get special attention during the aus season.

The framework for price stabilization implies a planning shift from a quantity-targeted to a price-targeted approach in the management of the public food system. The model developed specifies a price band in annual prices and links this band to the seasonal prices, keeping in view both cost and price stability. The price band in effect eliminates both super- and subnormal profits from private trade operations in foodgrains. The results indicate that a successful price stabilization program will substantially reduce pressure on the rationing system, and the process can be even more effective if pricing of rationed foodgrains, particularly ration prices for priority groups, is coordinated with market prices. A simulation exercise shows that if the proposed mode of stabilization had been operative during 1976-84, the fluctuation in annual prices would have varied from 3.4 to 23.1 percent, compared with variations of -17.3 to 41.3 percent under the existing system. Seasonal prices vary by a stable 15 percent every year under the proposed model, compared with actual prices, which varied from a low of 13.8 percent in 1980/81 to a high of 37.8 percent in the following year.

INTRODUCTION

Stabilization of prices, particularly of major foodgrains, is a serious concern of most developing countries. There are two types of temporal variations in prices: interyear and intrayear. The intrayear variation is generally called the seasonality of prices. The distinction between the two types is important in the context of policy instruments that are brought to bear on prices in order to contain extreme fluctuations. Public procurement in the harvest season and sales in the peak-price season are well-known policy instruments for combating seasonal fluctuations in foodgrain prices. Similarly, buffer stocks and export and import policies in foodgrains are commonly used to manage interyear variations in food prices and supply. Many developing countries spend a substantial share of their budgetary and administrative resources in controlling these temporal variations in prices. Therefore, issues and relations underlying price fluctuations need to be properly understood before formulating and implementing such costly policies.

The understanding of price stabilization problems and their potential solutions requires the following information. First, it is necessary to identify and examine conceptual issues involved in the assessment of benefits and costs and the underlying analytic approach of price stabilization. Second, the extent and nature of instability in prices of a commodity have to be quantitatively estimated, disentangling the real from nominal effects. Third, the underlying causes of unstable prices have to be identified in order to determine the influence of random elements as opposed to systematic factors. Fourth, before formulating any public stabilization policy, it is essential to know whether markets where private traders operate are integrated. If markets are not integrated, then many assumptions of aggregate analysis (for example, estimates of supply and demand parameters from aggregate relations) are violated. Finally, to make this information useful for practical operation, it is desirable to formulate an approach to price stabilization appropriate within a specific context. These are the objectives of this study for Bangladesh.

Price stabilization is essentially a short-run problem. Therefore, the policy instruments chosen should reflect the contemporary situation and pragmatic considerations. But probing into the dynamics of current situations by examining the historical behavior of prices in relation to structural changes in the economy is virtually unavoidable. Thus it is necessary to look backward as well as forward. Three particular aspects of Bangladesh's history receive specific analytic attention here. The first relates to the transition from a predominantly subsistence economy to a moderately commercialized one and the implications of that for variability in prices. The second relates to the effect of modern high-yielding varieties (HYVs) of rice on seasonality of prices. The third concerns data as well as behavior of price regimes before and after Bangladesh achieved independence in 1971.

Serious problems exist in pursuing price analysis covering the period 1971 through 1974, years of extraordinary social and economic disruptions in Bangladesh. Similarly, statistics such as personal income, imports, and money supply for the 1960s, when Bangladesh was a part of Pakistan, are suspect. Because of these problems, the analysis may seem unbalanced to readers who are not conversant with Bangladesh, but they are real issues that deserve to be explicitly recognized.

Methodology

To achieve the objectives of the study, four main methodological steps are necessary. First, nominal prices are decomposed into trend, seasonal, and irregular components. Second, causes of price movements are analyzed. Third, the degree of market integration is measured, and fourth, target annual average prices are predicted, and the annual average is linked with the seasonal factors to arrive at seasonal target prices for stabilization. These methods are explained in the sections where each task is discussed.

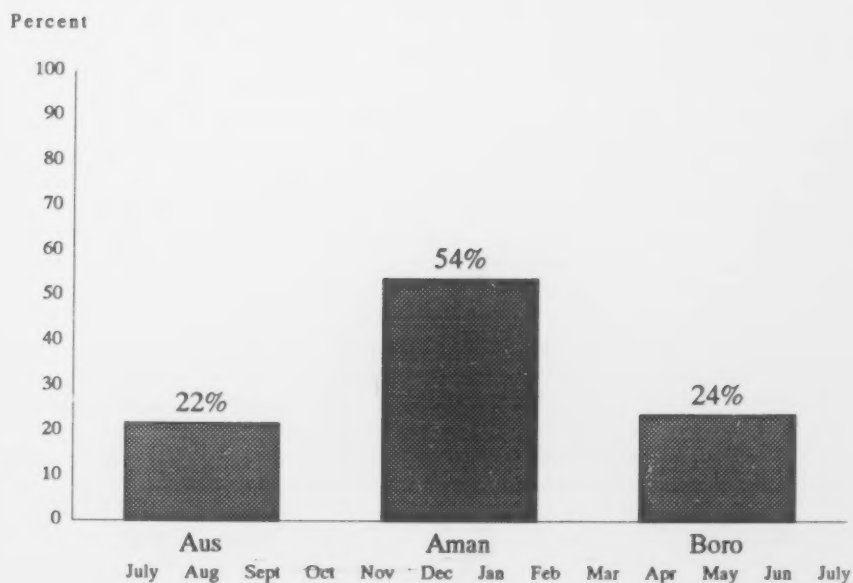
Data

The data used in the analyses are the wholesale monthly prices of coarse varieties of rice collected by the Department of Agricultural Marketing of the government of Bangladesh. Government price data include prices for three qualities of rice: fine, medium, and coarse. With the adoption of HYVs of rice, which are all coarse quality, the share of coarse rice in the total rice supply has increased. Currently coarse rice has the largest share, and coarse and medium rice together compose more than 90 percent of rice supply in the market. The use of coarse rice prices here should not invalidate the conclusions on the behavior of rice prices in general. The prices of various qualities of rice are closely correlated. The simple correlation coefficient between prices of coarse and medium-quality rice during 1975-84 is 0.9986 and highly significant. However, in a rising phase of rice prices, the price of coarse rice rises slightly faster than the price of medium. Similarly, in a falling phase, the price of coarse rice declines faster than the price of medium rice. As prices change, consumers in the middle-income bracket who shift back and forth between the two qualities of rice cause this phenomenon.

The national average price of any given quality is based on prices of about 350 markets spread throughout Bangladesh. However, the average is not weighted to reflect the size of the share of each market. Nor does the average explicitly reflect the various types of rice that are produced and marketed in various seasons. There are three seasons for rice harvests—aus, aman, and boro. The span of harvest time and the share of production for each of the three types of rice are shown in Figure 1.

The share of harvest for each season is shown as a flat figure even though arrival at market or actual harvest is concentrated in certain months, depending on the location. Generally, the aus harvest is concentrated in July-August, aman in December-January, and boro in May-June. Most rice grown in the aus season is coarse rice. Moreover, rice harvested in this season generally has a high moisture content; therefore, prices quoted in the market could vary widely due to varying degrees of moisture. Local varieties of rice harvested in aman and boro seasons consist of fine, medium, and coarse varieties.

Figure 1—Time spans of harvest seasons of rice and shares of aus, aman, and boro season harvests in total rice harvest, averages for 1982-84



Source: Computed from data in Bangladesh, Bureau of Statistics, *Statistical Yearbook 1985/86* (Dhaka: BBS, 1986).

PRICE STABILIZATION ISSUES

Whether price stabilization is economically rational or not is a fundamental issue. Economists approach this issue by comparing economic benefits from a stabilization program with its cost. But in fact most low-income, developing countries, including Bangladesh, operate some sort of stabilization program, particularly in foodgrains, even if such programs are frequently wasteful. To ask them to dismantle the programs has not been effective in the past and is not expected to be so in the near future. This is partly because unstable prices have political consequences and partly because policy-makers are concerned about the effects of periodic food scarcity, which can result in starvation and serious malnutrition. In addition, occasional sharply falling prices during harvest season can undermine the confidence in markets of producers and policymakers. Therefore, logic dictates a need for a stabilization mechanism that would minimize economic waste but preserve the elements that address food security and price support concerns arising from severe price instability. This is the approach taken in this study on rice price stabilization in Bangladesh. Until empirically tested alternatives to price stabilization are available, the emphasis on improvement of the operation of stabilization programs seems valid.

Even though this approach has been adopted here, the standard analysis of benefits and costs of stabilization is not irrelevant. The theoretical framework used historically in most empirical investigations of commodity price stabilization is the simple Marshallian partial equilibrium analysis of a closed economy developed by Waugh (1944) and Oi (1961) and synthesized by Massell (1969, 1970). Such a simple model is often inadequate for empirical application in dynamic circumstances, but it captures elemental effects of stabilization. However, some economists have raised serious doubts about the use of this approach in empirical investigations. Cochrane (1980) argues that "welfare analysis based upon the concepts of consumer and producer surplus has not in the past made, and will not in the future make, any recognizable contribution to the making of decisions by the United States, other developed countries, the less-developed nations, or the international agencies either to initiate commodity stabilization programs or to reject them." The use of the concepts, however, persists in economic analyses because neat alternatives are absent.

The assumption of a closed economy in the application of the concept is not considered a serious constraint. Most developing countries, Bangladesh in particular, do not allow open external trade in foodgrains even though they depend on public imports or exports to cushion the stocks of foodgrains. This control of foodgrain trade by the public sector makes the closed-economy model relevant. A brief exposition of the partial-equilibrium model is presented below.

Figures 2-5 indicate the income and welfare effects of price stabilization. Figure 2 shows a standard linear supply-demand relationship with two equally probable supply curves— S_1 and S_2 . The third curve, S_3 , represents an average of the other two. With supply fluctuating between the two extremes over time and without price stabilization, producers' average revenue is $(OP_2 \cdot OQ_2 + OP_1 \cdot OQ_1)/2$. Upon intervening, the government or buffer stock agency would buy Q_0Q_4 in the period of high supply (S_1) to maintain price at P_0 , whereas it would sell Q_0Q_1 during a poor harvest (S_2). In this

Figure 2—Welfare effects with linear supply-demand relations

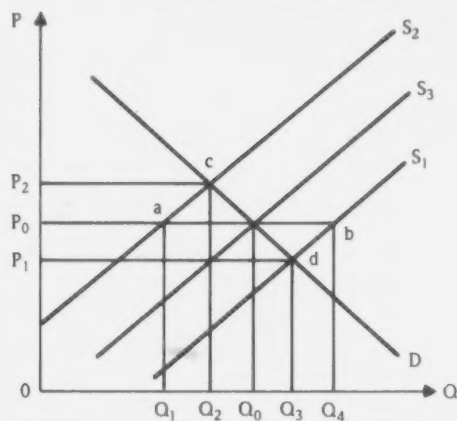


Figure 3—Welfare effects with shifting supply curve

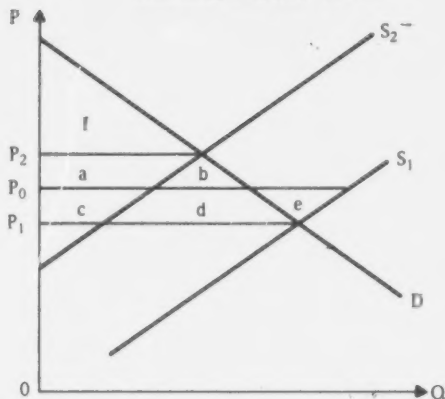


Figure 4—Welfare effects with shifting demand curve

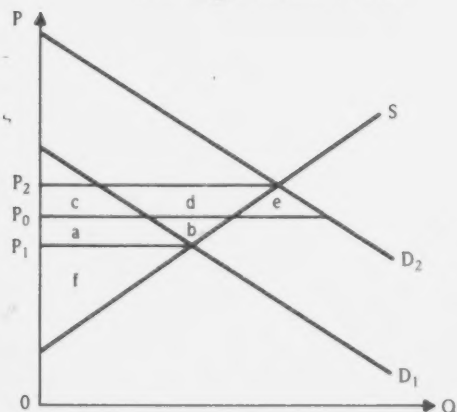
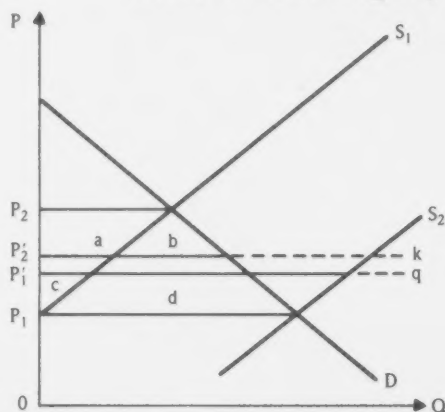


Figure 5—Welfare effects including cost of buffer stock agency



case price stabilization raises the variability of gross revenue while at the same time increasing its mean. Following this static framework, Waugh's 1944 seminal work established that consumers having a negatively sloped demand curve gain from price variation and lose from price stabilization. He focused only on consumers. Following Waugh's line of reasoning, Oi (1961) demonstrated that with a positively sloped supply curve producers also benefit from price instability and lose from stabilization. He focused only on producers. Massell (1969) combined both producers' and consumers' welfare and illustrated that the distribution of welfare changes is determined by the origin of the random price fluctuation, and that price stabilization produces a net gain to the society (producers and consumers taken together).

Massell uses the linear model with prices fluctuating from shifts in either supply or demand or both, with stabilization being implemented through a buffer stock. Figure

3 shows the case of shifting supply, with supply curves S_1 and S_2 each occurring 50 percent of the time. The price P_0 is a price that can be achieved with costless storage activity, that is, P_0 is the buying and selling price of the buffer stock agency (this unrealistic assumption of costless storage is relaxed below). By preventing the price from falling to P_1 , producers gain revenue $(c + d + e)$, while consumers lose $(c + d)$, so that there is a net gain in the system of e . Preventing the price from rising to P_2 benefits consumers by $a + b$ and costs producers only a in forgone revenue, and there is a net gain of b . Hence stabilization gives producers a net gain of $c + d + e - a$ and consumers a net loss of $c + d - a - b$. Therefore the total net gain by producers and consumers together is $e + b$. Massell (1969) notes the welfare problems associated with this type of abstraction but remarks that "...producers are able to compensate consumers so as to leave both groups better off."

Figure 4 shows price fluctuations resulting from demand shifts from D_1 to D_2 (again each curve is equally likely). Mirroring the supply movement, the net gain to consumers is $c + d + e - a$, and the net loss to producers is $c + d - a - b$, so that the overall gain equals $e + b$. The model incorporates positive storage costs (Figure 5) when the buffer stock agency operates to stabilize prices within a range of $P_1 P_2$ so that it earns a profit of $P_2 - P_1$ on each unit bought or sold. These profits can be used to offset storage, interest, insurance, and other costs of maintaining stocks. In Figure 5, $P'_2 = k$ and $P'_1 = q$ are costs per unit when the level of stabilization is set at P'_2 and P'_1 , respectively. Since costs exist, partial price stabilization will be closer to optimal than absolute price stabilization within the context of this model.

Turnovsky (1974) points out that the Waugh-Oi-Massell analysis assumes that demand and supply depend upon actual prices and deal with "a situation of price variability rather than price uncertainty, since an important aspect of this latter case is the fact that some decisions must be made on the basis of imperfect information." Turnovsky examined the Waugh-Oi-Massell approach under the more realistic assumption that producers' decisions were based on expected prices, and he considered two different processes by which producers anticipate prices—rational expectations and adaptive expectations. He found that whether or not the Oi results continue to hold depends on the price expectation mechanism as well as the autoregressive properties of the stochastic disturbances, while the Waugh and Massell results hold under both expectation hypotheses.

Although a number of researchers have pointed out various shortcomings of the static model, Newbery and Stiglitz (1981) provide a more comprehensive framework for examining welfare issues related to commodity price stabilization. Some important issues that they focus on will be examined here in the context of Bangladesh and the implications of economic models. In general, Newbery and Stiglitz are against public stabilization policies even though they find occasional positive gains.

Does Price Stabilization Destabilize Income?

Income from the crop is the product of its price times the quantity, PQ . Generally price and quantity are inversely related; price rises when production falls, and price falls when production rises. This relation is apparent in annual data of Bangladesh. Assuming a constant elasticity of demand, ϵ , the relation between variability of income (Y) and price is $\text{var}(\log Y) = (1 - 1/\epsilon)^2 \text{var}(\log Q)$. When price is absolutely stabilized, the only source of variability in income is production. Whether price stabilization reduces or increases variance in income depends on whether price elasticity of demand is greater or less than 0.5 in absolute terms and on the extent of marketed surplus.

When price elasticity of demand is 1.0, the variance in income is zero. When price elasticity of demand is less than 1.0 but greater than 0.5 and supply fluctuation is the source of price fluctuation, then stabilization of prices increases instability in income from the particular crop. Of course, supply is generally the source of variability in prices of rice in Bangladesh (that is, variability of imports and domestic production), and the price elasticity of demand for rice ranges from 0.4 to 0.6 (Pitt 1983, Ahmed 1981). This suggests that price stabilization in rice may increase instability in income from rice. But such a conclusion could be quite misleading in a dynamic sense.

The effects of rice price instability on jute prices and other sources of income are not zero for Bangladesh. The positive relations between the rice price and nominal wage rates, as well as various other prices, have been recorded in other studies (Ahmed 1981). These relations indicate that variability in nominal income from rice may rise with stabilization, but variability of real income as well as total household income is likely to be smaller with rice price stabilization than without it. Perhaps these dynamic factors led Newbery and Stiglitz (1981) to conclude that "the benefits of pure price stabilization schemes are likely to be relatively more important for small countries and likely to be greater in total, the more widespread is the production of the commodity." Rice is clearly a dominant crop in the agriculture of Bangladesh.

Farm Structure and Implications for Price Stabilization

The structure of farms in Bangladesh is such that 40 percent are deficit farms cultivating less than 1.0 acre each. They are deficit in the sense that they are net buyers of rice even in good harvest years. Another 30 percent, cultivating an area between 1.0 and 2.5 acres per household, are marginally self-sufficient in that, as a group, in good years they produce a small marketable surplus (see Table 1), but they may have to buy rice in bad harvest years. The remaining 30 percent of farms are surplus producers of rice in good years as well as bad. About 91 percent of the marketable surplus of rice is produced by this group, which fits the conventional definition of "producers" in the neoclassical framework of price analysis.

On the basis of farm size data for 1973/74 through 1977/78 from a study by Ahmed (1981), the relation of marketable surplus to gross production and prices is as follows. With a 1.00 percent change in rice production, the marketable surplus changes

Table 1—Share of farm groups in the total number of farms, in total area cultivated, and in marketable surplus

Farm Group	Share of Total Farm Households, 1983	Share of Total Land Area, 1983	Share of Marketable Surplus in Total Production, 1978
		(percent)	
Deficit farms (less than 1.0 acre)	40.4	7.8	0.0
Marginally self-sufficient (1.0 to 2.5 acres)	29.9	21.2	3.3
Surplus (more than 2.5 acres)	29.7	71.0	91.7

Source: Computed from Bangladesh Bureau of Statistics, *National Report on the 1983/84 Census of Agriculture and Livestock* (Dhaka: BBS, 1986).

in the same direction by 2.20 percent in the marginally self-sufficient group and by 1.50 percent in the surplus farm group. The overall elasticity is 1.56. With a 1.00 percent change in the rice price, the marketable surplus changes by 0.02 percent in the same direction, but only in the surplus farm group. In the marginally self-sufficient group, the price effect is not significant; even the direction is negative. This implies that such self-sufficient farms may have a backward-bending but weak supply curve. Such farmers can fulfill their cash obligations by selling a smaller quantity of rice when the price is high rather than a larger amount when the price is low.

On the basis of the foregoing relations and assuming a price elasticity of demand for rice of -0.5 and 1983/84 production, price, and marketing rates, the estimated benefits from price stabilization, following the short-run static framework, are shown in Table 2. The source of price change is entirely the random supply instability.

The estimates are based on a gross production level of 16.0 million tons of rice in 1983/84 and 4.6 million tons of marketable surplus. The price assumed is 260 taka (Tk) per maund.¹ This is the base from which changes are measured. Note that the magnitude of change is the main concern and the parameters of change are important in these measurements. The base-year statistics are of secondary importance.

The effects are drawn from short-run relations but the lessons derived from this simple exercise go far beyond the ones indicated by the economists mentioned earlier.

Effects on Consumers

The analysis in Table 2 and similar past analyses show that price stabilization is bad for consumers because consumers bear a net loss (Tk 26.1 million in Table 2). But the experiences of developing countries indicate that it is the consumer who demands price stabilization. Why this gap between reality and economic analysis? The source of this conflict between economic analysis and empirical experience may be found in the averaging of good and bad seasons. The economic analysis implies that a rational consumer, who saves when prices are low, enabling him to purchase when prices are high, is on average better off with price instability. In reality this does not happen where the level of poverty is high and capital markets are imperfect. An unsatiated consumer cannot hold back on consumption sufficiently during a low price season to save enough to help him avoid starvation in a high price season. He cannot plan with a time horizon that includes the two price situations, and therefore an average of the two situations is not applicable to him. The process of adjustment to a high price-low income situation in a country with widespread poverty may have further implications for future growth. A study by Jodha (1978), based on the Rajasthan drought, indicates that the affected population first reduces consumption, then defers committed obligations and reschedules current production activities. As the shock becomes more severe, they deplete inventories, livestock, and utensils; mortgage or sell land; and finally migrate to urban centers or other areas. Replacement of assets in good years becomes difficult not only because they can save little in good years but also because they have to sell cheap and buy dear. A study in Bangladesh records a similar process of adjustment by the poor (Ahmed 1981).

Price instability, therefore, has the potential for accelerating the process of pauperization. Price stabilization schemes, if implemented effectively, can reduce the effect of this process. In essence, such schemes impose discipline upon the consumer so that he consumes less when prices fall. Such schemes also prevent consumption from falling

¹ One maund equals 37.32 kilograms. At the 1984/85 official rate of exchange, US\$1.00 = Tk 30.

Table 2—Estimated short-run gains to producers and consumers from price stabilization, 1983/84

Types of Consumers and Producers	Low-Price Season ^a	High-Price Season ^a	Net Loss or Gain Over Two Seasons
	(Tk million)		
Consumers	-349.40	323.27	-26.13
Producers:	403.88	-270.93	132.95
Deficit farms ^b	0.00	0.00	...
Marginally self-sufficient farms	35.36	-20.49	14.87
Surplus farms	368.52	-250.44	118.08

Sources: Estimated on the basis of parameters in Table 2, and production data from Bangladesh, Bureau of Statistics, *Statistical Yearbook of Bangladesh 1985* (Dhaka: BBS, 1985).

Note: Minus sign indicates a loss.

^a The low price season is when production increases by 10 percent without a change in demand, and the high price season is when production falls by 10 percent.

^b Deficit farms are net buyers, so the effect of price stabilization on this group is included in the consumer category.

precariouly when prices rise. Because of an adverse economic environment, a poor consumer will fail to follow the same rational consumption path as that implied in price stabilization if left alone to face market forces.

Effects on Producers

Table 2 reveals some interesting facets of price stabilization relevant to producers. Again, the average of good and bad harvest seasons masks a significant effect of price stabilization. It is clear from the numbers that the deleterious effect on producers of a price slump in a good harvest season is much larger than the beneficial effect when the harvest is poor and prices are high. This adverse effect in a falling price regime, in the absence of a stabilization scheme, is about 47 percent larger than the positive effect for surplus farmers during a rising price regime. For marginally self-sufficient farmers the deleterious effect of low prices is 75 percent larger than the positive effect of the high price scenario. In Bangladesh, when agricultural technology is progressing vigorously, the downward fluctuations tend to be more numerous, albeit less severe, than upward fluctuations, as will be shown later. This makes the case for stabilization much more convincing for a technologically oriented growth strategy than for traditional agriculture. Therefore, price stabilization, particularly price supports when harvests are good, should be a critical concern of producers with a marketable surplus.

Finally, the assumption that all farmers are net surplus producers of rice is not correct for Bangladesh. It is wrong to assume that the effect on deficit farmers is the same as that on consumers. These deficit farmers in practice sell some rice just after harvest at low postharvest prices to meet urgent cash obligations. They then must buy more during other seasons when prices are higher. They have little access to the formal credit market to avoid this situation (see Ahmed and Hossain 1988).

Rice Price Stabilization and Jute Production

One important issue raised by Newbery and Stiglitz (1981, 27) concerns the effect of price stabilization in one crop on production of and income from other crops. In the context of Bangladesh, the effect of rice prices on jute production deserves particular attention.

In 1981-84 jute area constituted only about 4 percent of gross cropped area, compared with rice, which covered about 80 percent. As a result, a change in relative prices of rice and jute caused a much sharper change in jute production than in rice production. Estimates of short-run supply elasticity of jute range between 0.50 and 0.60, while those for rice range between 0.07 and 0.15 (Rahman 1986). Only a small part of the tiny price elasticity of rice can be attributed to jute, whereas most of the price response in jute is attributable to rice. The substitutability of the two crops in land use and the difference in technological progress between the two are the causes. Thus, rice price stabilization contributes to jute price stabilization, but jute price stabilization has little effect on rice price stability. Analyzing rice price stabilization without treating jute explicitly does not change the conclusion on rice prices substantively.

Thus, rice prices should enter into any program that attempts to stabilize jute prices. Although stabilization of jute prices has continued to be an ineffective and expensive venture, the government has not been able to forsake the idea of jute price stabilization completely. It has been observed that the instability in prices and supply of jute has contributed to the loss of world demand for Bangladesh's jute as much as the competition from synthetic substitutes (Kibria 1985). The uncertain supply of jute has eroded the confidence of foreign buyers. Switches from jute to synthetics in times of shortage and high price are asymmetrical in the sense that a reverse movement during a glut in supply and low prices does not occur. Rice price stabilization would therefore exert a positive influence on jute price stability and jute supply.

Cost of Stabilization

Perhaps the cost of stabilization ought to be the main concern, not suspicion about its beneficial effects. Even in this area, there are three distinct issues that must be carefully analyzed to calculate the cost of a stabilization program.

First, looking back to Figure 2, a static analysis would show that a stabilization agency would have to procure the quantity Q_0Q_4 during a good harvest season and to sell from its stock quantity Q_0Q_1 on the open market during a poor harvest year. Therefore, the average stock and cost of the operation would be determined by these quantities. The operation costs would include the interest cost of the financial capital required to purchase and sell the stock, transport and handling charges, rent of physical storage facilities, and any wastage of stock that may occur in the operation. Of these, the interest cost is by far the largest component, and it is dependent on the quantity procured and distributed.

In real-world operation, the actual stock to be maintained for price stabilization would be substantially different from the average of Q_0Q_1 and Q_0Q_4 shown by Figure 2. The difference arises from the behavior of private traders, including surplus farmers. If these traders and farmers expected that the government, for budgetary or other reasons, could not maintain the price at the announced level, they might speculate against the government position by postponing, selling, or unloading all their stock on the market to make larger profits. Such behavior by farmers and traders implies that the government would have to buy or sell more than the quantity estimated on the basis of no change in the expectations of producers and traders. It may be noted in Table 1 that only about 30 percent of producers produce virtually all of the marketable surplus. Such concentration of marketable surplus implies that the expectation of—not necessarily collusion within—this relatively small group can create severe instability in market prices of rice. Therefore, stability in the government's actions is an important

factor in conditioning traders' and farmers' expectations and potentially reducing the costs of a program. In any case, such fine-tuning may never be perfect. Actual stock for price stabilization, and therefore the cost, may have to be larger than indicated by the static models mentioned earlier.

Second, explicit budgetary costs of the ongoing procurement and distribution of foodgrains are often assumed to be the costs of price stabilization, but this is often not a true assessment. Frequently this budgetary cost includes the cost of food subsidy as well as the cost of stabilization. It is important that the two elements be separated in order to determine the pure cost of stabilization.

Third, if the two objectives of transfer of income through food subsidy and price stabilization are attempted through the same program, as is usually the case, then the treatment of cost for stabilization requires a different approach than is conventionally followed. The administrative cost, physical storage cost, and part of the stocking cost that are required for transfer of income through food subsidy can be assumed to be fixed costs that a government will carry in any case. The additional cost required to carry out the objective of price stabilization is then the average variable cost, which can be compared with the estimated benefits of price stabilization. If this view is correct, then the cost of price stabilization would not be as expensive as is normally assumed. This cost issue will be discussed further subsequently.

Price stabilization involves a number of other issues, including, for example, the macroeconomic effect and the effect on risk behavior of farmers. For developing economies, these indirect effects of price stabilization are far more important than the direct effects discussed in this section. The effect of a stable price environment on investment decisions by entrepreneurs and the resulting impact on economic growth are particularly significant. But there are enormous difficulties in the measurement of indirect effects, and the subject has received little attention in empirical research. These issues are, however, beyond the scope of this paper.

This brief exposition of conceptual issues is included here to help explain the complexities of price stabilization in terms that are understandable to policymakers. Obviously, there is considerable room for pragmatism. On this note, the nature and extent of price fluctuations in rice markets will next be examined.

FLUCTUATION IN RICE PRICES

The problem of instability in prices is a source of great concern to farmers and consumers in low-income countries. Low-income consumers are extraordinarily vulnerable to sharp increases in food prices. The lowest 20 percent in the income distribution makes 10 times as much adjustment to increases in foodgrain prices as the top 5 percent (Mellor 1978). Naturally, the starting point of any exercise for stabilizing prices is to probe into the nature and extent of price fluctuation. In this section, the fluctuations in annual and monthly rice prices are examined with particular emphasis on decomposition of nominal prices into trend, seasonal, and irregular components.

Fluctuation of Annual Prices

Fluctuation can be measured in a number of ways. A price change in a given year relative to the price of the preceding year is an often-referred-to measure of nominal fluctuation. Such a measure fails to distinguish between trend and random elements of fluctuation. The trend element can be separated from the random component by a variety of procedures, such as simple linear or log-linear regressions or detrending by a moving-average technique. In this study, a linear regression of annual prices on time gives an extremely poor fit of the trend line, and hence wide fluctuation in the residuals. In Table 3, the fluctuations are measured in reference to the previous year's price, as well as from a log-linear trend and a moving average.

Year-to-year fluctuations of nominal prices were high during 1972-75 (column 2 of Table 3). Excluding the years from 1972 to 1975, the year-to-year fluctuation in nominal prices during 1976-84 ranged from 4 to 41 percent, compared with a range of 1 to 32 percent during 1960-70. Year-to-year nominal fluctuations greater than 10 percent occurred in 7 out of 9 years in the former period, compared with 5 out of 10 years in the latter. Therefore, by this measure, the 1960-70 decade had more price stability than the 1976-84 period.

In order to detrend prices so that fluctuations around the trend can provide a more meaningful measure of variability, two methods are adopted here: a moving average and a log-linear function for trend. A comparison of Figure 6 with Figure 7 clearly indicates that the moving average method provides a better fit. The deviations of actual prices from both these trend estimates are shown in columns 4 and 5 of Table 3. When the trend-cycle element of fluctuation is reduced, the pattern remains similar to year-to-year nominal fluctuation. This is, however, not the case with the log-linear detrending, which, because of its poorer fit, shows more fluctuation during 1960-70 compared with that in 1976-84. Deviations from the moving average indicate that the range of fluctuation in prices was between 1 and 18 percent, plus or minus, during 1976-84, compared with 2 and 13 percent during 1960-70. Figure 7 shows that deviations were slightly more ample during 1976-84 than those in 1960-70.

To demonstrate fluctuation in real prices, it is necessary to deflate nominal prices by some price index. Here the price index of manufactured consumer goods is used for this purpose because the rice weight is very high in the general price index in Bangladesh. The pattern of fluctuation in real prices is shown in Figure 8. Qualitatively,

Table 3—Fluctuation in annual prices of rice, 1960-84

Year	Actual Price	Change from Previous Year	Moving Average Price	Deviation of Actual Price from Moving Average	Deviation of Actual from Log-Linear Trend
	(Tk/maund)	(percent)	(Tk/maund)	(percent)	
1960	24.50	...	...	...	35.0
1961	25.20	3.0	25.60	-2.0	24.0
1962	27.10	8.0	25.50	6.0	18.0
1963	24.20	-11.0	25.30	-4.0	-6.0
1964	24.50	1.0	25.90	-5.0	15.0
1965	29.10	19.0	30.60	-5.0	-11.0
1966	38.40	32.0	34.10	13.0	5.0
1967	34.70	-10.0	37.30	-7.0	-16.0
1968	38.70	12.0	37.60	3.0	-17.0
1969	39.50	2.0	38.50	3.0	-24.0
1970	37.20	-6.0	40.60	-8.0	-37.0
1971	45.20	22.0	51.80	-13.0	-31.0
1972	73.10	62.0	71.99	2.0	-1.0
1973	97.50	33.0	126.00	-23.0	17.0
1974	207.30	113.0	145.60	42.0	121.0
1975	132.10	-36.0	149.80	-12.0	25.0
1976	110.00	-17.0	127.00	-13.0	-7.0
1977	139.00	26.0	131.30	6.0	4.0
1978	144.90	4.0	162.90	-11.0	-3.0
1979	204.70	41.0	172.80	18.0	21.0
1980	168.90	-17.0	196.60	-14.0	-11.0
1981	216.30	28.0	208.30	4.0	1.0
1982	239.60	11.0	237.70	1.0	0.0
1983	257.20	7.0	261.10	-1.0	-5.0
1984	286.47	11.0	...	...	-6.0

Source: Actual nominal prices are from data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

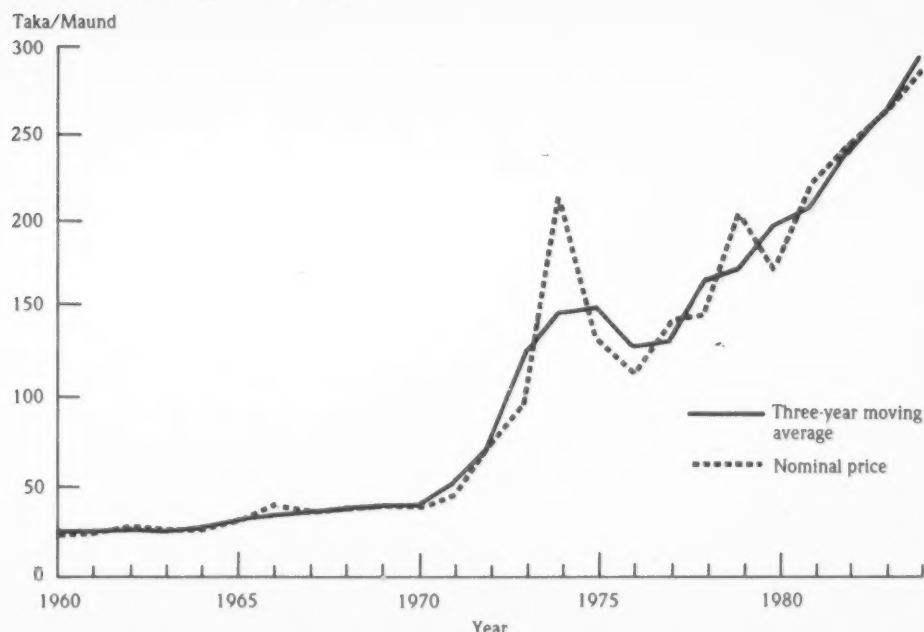
the pattern is not much different from that in the foregoing discussion. However, no price index of manufactured goods is available for the 1960-70 period. Therefore that period is excluded from the conclusions. For the period 1976-83, the index of manufactured goods prices shows a slightly higher rate-of-trend increase than nominal rice prices, thus producing a slightly declining trend of real rice prices. However, the movements of rice and manufactured goods prices are such that the degree of fluctuation in real rice prices is smaller than that of nominal prices.

Fluctuation of Monthly Prices

The fluctuations in monthly prices are examined in two steps. First, the extent and pattern of month-to-month variations in nominal prices are probed. Second, the nominal prices are decomposed into trend, pure seasonal, and irregular components to highlight the contributions of each of the components to the overall fluctuation in nominal prices. This brings out the underlying seasonality in rice prices.

The extent of fluctuations in monthly prices for the 1960s, the 1970s, and the early 1980s is shown in Table 4. Two indicators are presented. The first indicator measures the simple range—that is, the difference between the lowest and highest

Figure 6—Nominal annual rice prices compared with three-year moving averages, 1968-84



Source: Based on data from Bangladesh Bureau of Statistics, *National Report on the 1983/84 Census of Agriculture and Livestock* (Dhaka: BBS, 1986).

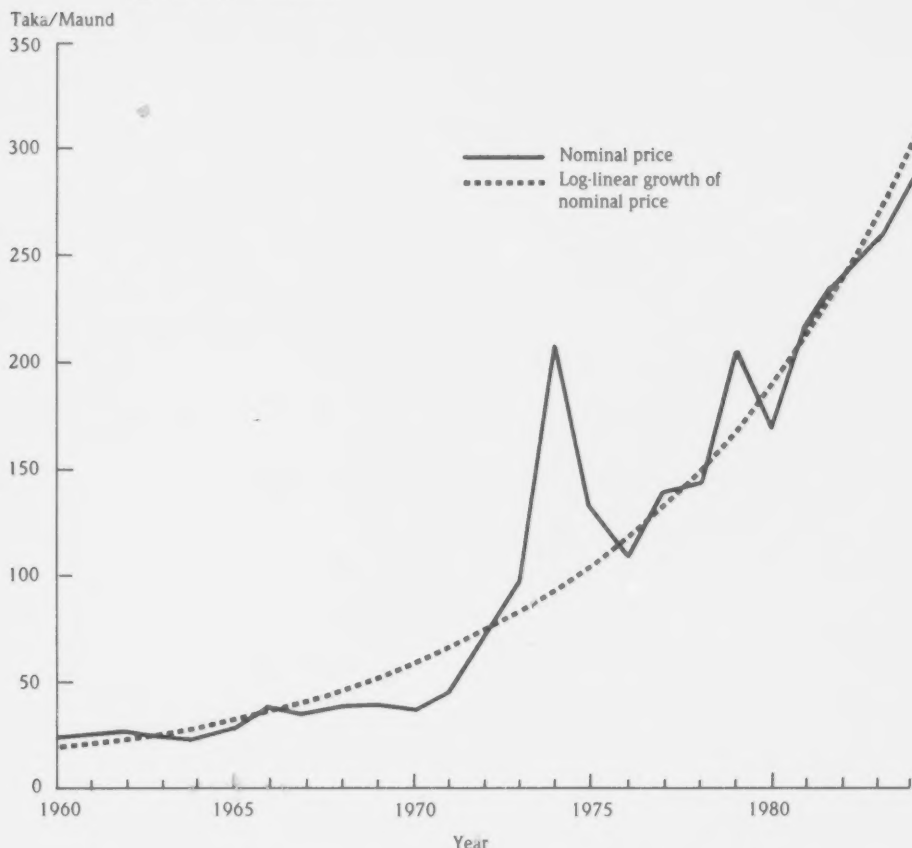
monthly price indexes. The monthly price indexes are based, for every year, on the January price (January equals 100). The second indicator is the coefficient of variation, which is defined as the standard deviation of monthly prices in a year, deflated by the average price. This indicator is more comprehensive than the first and can be interpreted as a measure of fluctuation expressed as a percentage of average price. The following conclusions can be derived from information in Table 4.

1. As indicated by the first indicator, monthly price fluctuations exceeded 35 percentage points in only 2 years out of 10 (that is, once every 5 years) during the period 1960-70. In the period 1971-75, the years of civil war and postwar turmoil and famine in Bangladesh, monthly nominal prices fluctuated more than 35 percentage points in all of these years. During the period 1976-84, fluctuations in monthly nominal prices exceeded 35 points in 2 out of 9 years.

2. December-January, particularly January, is the period when rice prices are low in Bangladesh. Exceptions to this rule have occurred only three times in a period of 24 years. These exceptions can be traced to the beginnings or ends of abnormal price movements and the consequent adjustment process. The low-price period of December-January clearly coincides with the harvest of the main rice crop, the aman rice.

3. Unlike the distribution of low-price points, the high-price points are not distributed so consistently over specific months. High-price points in rice prices generally occurred in the months of July and October-November during the 1960s. During the

Figure 7—Nominal annual rice prices compared with log-linear annual growth, 1968-84

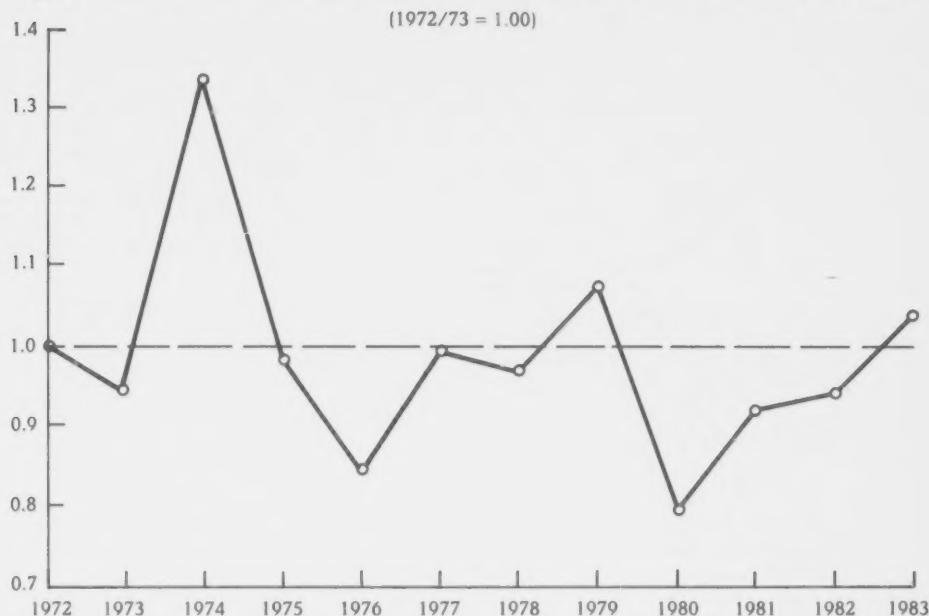


Source: Based on data from Bangladesh Bureau of Statistics, *National Report on the 1983/84 Census of Agriculture and Livestock* (Dhaka: BBS, 1986).

late 1970s and early 1980s, high-price points occurred more frequently in May and August than in other months. The incidence of high prices in October-November thus appears to have diminished in the 1976-84 period compared with 1960-70.

Another way of looking at the variations in monthly nominal prices is to consider prices at particular months over a number of years (say January prices of 1960-70) and to measure the coefficient of variation around a simple time trend (Table 5). The statistics in Table 5 indicate that the extent of variation in monthly prices was higher in 1971-75 compared with either 1960-70 or 1976-84. The early years show a relatively constant coefficient of variation across months, whereas the latter two periods exhibit a wide range from month to month. For 1976-84 the high coefficients from July to October raise a question as to whether production with new technology, most of which is harvested during July to October, has caused this phenomenon. In general, there has been little change from the 1960s to the recent period.

Figure 8—Ratio of the rice index to the manufactured goods index, 1972-83



Source: Computed from Bangladesh Bureau of Statistics, *Statistical Yearbook 1985/86* (Dhaka: BBS, 1986).

Decomposition of Nominal Prices

There are numerous methods for seasonally adjusting economic time series, all of which are based on the premise that seasonal fluctuations can be measured in an original nominal series and separated from trend, cyclical, and irregular fluctuations. The seasonal component is defined as the intrayear pattern of variation, which is repeated constantly or evolves from year to year. The trend-cycle component includes the long-term trend and business cycle, if any. The irregular component is composed of residual variations, such as the sudden impact of political events, the effect of abnormal weather conditions, and reporting and sampling errors. The series adjusted for the seasonality factor consists of trend-cycle and irregular components. Similarly, the series adjusted for trend-cycle and irregular factors consists of the pure seasonal component.

The method for decomposition of the original price series into trend-cycle, seasonal, and irregular factors in this study is based on the X-11 procedure developed by the U.S. Bureau of the Census for adjusting economic series for seasonality (U.S. Department of Commerce 1976). Among the various approaches considered, the X-11 proved the most flexible and appropriate for this price series. The procedure has the advantage of relatively precise measurements of the components and enormous flexibility in application for various types of time series. A brief description of the technical ingredients of the X-11 procedure is presented in Appendix 1 of this study.

In summary, the moving-average technique is the central element of the procedure, and iterative steps of moving averages are constructed to arrive at final results. A choice

Table 4—Extent of fluctuation in monthly nominal prices of rice, 1960-84

Year	Fluctuation ^a	Coefficient of Variation ^b	Month of Lowest Price Point	Month of Highest Price Point
	(percent)			
1960	39.9	0.113	January	July
1961	23.4	0.055	January	November
1962	19.3	0.062	January	July
1963	16.4	0.054	December	July
1964	23.9	0.073	April	October
1965	30.3	0.087	January	October
1966	58.9	0.167	January	October
1967	20.4	0.062	January	July
1968	31.3	0.105	February	November
1969	26.7	0.073	January	October
1970	21.4	0.074	December	July
1971	36.3	0.102	January	November
1972	84.0	0.213	January	October
1973	44.7	0.108	January	June
1974	154.5	0.362	January	October
1975	84.0	0.244	December	April
1976	10.8	0.033	July	February
1977	52.9	0.138	January	August
1978	17.6	0.046	January	May
1979	70.4	0.191	January	August
1980	22.9	0.093	December	May
1981	33.9	0.088	January	December
1982	29.2	0.107	January	May
1983	19.2	0.048	January	November
1984	26.7	0.071	January	October

Source: Computed from price data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

^a Price fluctuation is measured as the difference between the highest and lowest index numbers; the index number of a month is based on the January price as 100 and constructed separately for months in a year.

^b The coefficient of variation is the standard deviation divided by the mean.

Table 5—Coefficients of variation of monthly rice prices in 1960-70, 1971-75, and 1976-84

Month	Coefficient of Variation		
	1960-70	1971-75	1976-84
January	0.104	0.429	0.089
February	0.133	0.464	0.100
March	0.134	0.487	0.107
April	0.149	0.450	0.098
May	0.142	0.310	0.108
June	0.139	0.208	0.068
July	0.125	0.205	0.131
August	0.124	0.219	0.162
September	0.102	0.251	0.155
October	0.106	0.352	0.141
November	0.103	0.525	0.105
December	0.101	0.481	0.100

Source: Computed from price data in Table 4, which were provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

Note: The coefficients of variation are computed around a simple time trend.

of several moving averages is available in X-11 for estimating the trend-cycle component. The selection of the appropriate moving average for estimating the trend-cycle component is made on the basis of a preliminary analysis of the data, using the technique provided in the X-11 procedure. The extreme values of irregular components thus derived are replaced by neighboring values if the irregular values fall beyond 2.5σ (two standard deviations). Because of this smoothing adjustment in extreme values, the procedure may underestimate the irregular component, but it produces a consistent picture of seasonality.

Trend Cycle

When nominal prices are decomposed into trend, seasonal, and irregular components, the trend component of rice price is nonlinear and inclusive of cyclical elements. The trend price of rice was reasonably stable during the 1960s (1960-70), but rose sharply during the 1970s and early 1980s (1971-84), with occasional upward bursts in cyclical fashion. Even eliminating the cyclic component, the pure trend is not linear, but closely resembles an exponential growth curve and is consistent with the trend of inflation.

Seasonal Factors

The purely seasonal factors in rice prices are shown in Tables 6 and 7 and Figure 9. The following conclusions emerge clearly from the tables and graphs.

First, comparing 1960-70 and 1976-84 in Figure 9, it can be seen that in the first period the band of seasonality (breadth of the lowest and highest seasonality factors)

Table 6—Index of pure seasonality in monthly rice prices, 1960-84

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	90.7	93.9	95.1	98.7	101.5	104.7	107.8	104.5	100.6	100.4	102.9	99.2
1961	90.9	93.9	95.1	98.6	101.3	104.5	107.7	104.3	100.9	100.8	103.1	99.3
1962	91.2	93.5	95.2	98.3	101.3	103.8	107.2	104.2	101.7	101.7	103.5	99.7
1963	91.3	92.7	95.2	97.8	101.1	103.1	106.7	104.3	102.5	102.8	104.0	99.7
1964	91.1	91.9	95.4	97.5	100.8	102.5	106.2	104.7	102.9	104.0	104.5	99.9
1965	90.4	91.3	95.4	97.1	100.5	102.2	106.1	105.5	103.1	104.7	104.9	99.7
1966	89.5	90.9	95.4	97.0	100.6	102.2	106.2	106.0	102.9	105.3	105.2	99.5
1967	88.5	90.5	95.0	97.3	101.0	102.7	106.7	106.5	102.4	105.3	105.2	99.0
1968	87.8	90.4	94.4	97.8	101.9	103.8	106.9	106.4	101.5	105.1	105.2	98.6
1969	87.4	90.2	93.6	98.5	103.0	105.0	107.1	105.9	100.9	104.8	104.9	97.8
1970	87.2	90.2	93.1	99.2	104.6	106.3	106.9	104.7	100.5	104.6	104.7	97.0
1971	87.2	90.1	92.7	100.3	106.2	107.0	106.2	103.9	100.3	104.6	104.3	95.9
1972	87.3	90.2	93.3	100.9	107.7	107.4	104.9	103.2	100.1	104.7	103.7	95.1
1973	87.7	90.3	94.4	101.5	108.5	107.0	103.6	103.0	100.1	104.6	103.1	94.7
1974	88.2	90.6	96.1	101.7	108.8	106.1	102.7	103.1	100.3	104.4	102.6	94.6
1975	88.6	91.0	97.2	101.9	108.7	104.9	102.1	103.6	100.5	104.2	102.3	94.6
1976	89.1	91.5	97.8	101.6	108.3	103.9	101.9	104.0	100.8	103.7	102.1	94.5
1977	89.5	92.4	98.0	101.6	108.0	103.4	102.0	103.6	101.0	103.2	101.8	94.8
1978	89.9	93.3	98.1	101.8	108.1	103.3	101.9	102.9	100.5	102.3	101.6	94.9
1979	90.2	94.4	98.7	102.8	108.5	103.4	101.1	101.2	99.2	101.6	101.6	95.5
1980	90.8	95.5	99.9	104.0	108.7	103.6	99.8	99.4	97.6	101.1	101.6	95.8
1981	91.6	96.9	101.3	105.4	108.6	103.5	98.3	97.7	95.9	100.9	101.7	96.6
1982	92.4	98.1	102.4	106.4	108.2	103.1	97.0	96.7	94.7	100.9	102.0	97.4
1983	93.0	98.9	103.0	107.1	107.6	102.6	96.1	96.1	93.9	101.3	102.2	98.1
1984	93.3	99.2	103.2	107.4	107.2	102.3	95.6	95.8	93.6	101.7	102.5	98.1

Note: The procedure for computing the index is described in Appendix 1.

Table 7—Dispersion of the index of pure seasonality in rice prices, with low and high price months, 1960-84

Year	Range	Minimum	Maximum	Low Month	High Month
1960	17.14	90.68	107.82	January	July
1961	16.76	90.89	107.65	January	July
1962	16.00	91.17	107.17	January	July
1963	15.40	91.28	106.68	January	July
1964	15.12	91.07	106.19	January	July
1965	15.71	90.42	106.13	January	July
1966	16.76	89.46	106.22	January	July
1967	18.11	88.55	106.66	January	July
1968	19.12	87.79	106.91	January	July
1969	19.75	87.40	106.91	January	July
1970	19.66	87.19	106.85	January	July
1971	19.85	87.19	107.04	January	June
1972	20.38	87.28	107.66	January	May
1973	20.77	87.71	108.48	January	May
1974	20.59	88.17	108.76	January	May
1975	20.01	88.65	108.66	January	May
1976	19.18	89.14	108.32	January	May
1977	18.53	89.49	108.02	January	May
1978	18.20	89.85	108.05	January	May
1979	18.29	90.23	108.52	January	May
1980	17.88	90.81	108.69	January	May
1981	17.02	91.55	108.57	January	May
1982	15.73	92.44	108.17	January	May
1983	14.63	93.01	107.64	January	May
1984	14.12	93.29	107.41	January	April

Source: This index is based on the seasonality index in Table 6.

gradually widened. The opposite pattern (a gradual narrowing) can be discerned in the latter period (1976-84). However, the downward fluctuations were increasingly smaller during 1976-84 compared with the first period. The difference in upward fluctuation between the two periods is not so sharp.

Second, as far as the seasonality factor is concerned, the lowest factor price has occurred in the month of January in all periods, although a new strong second low is evident in the 1976-84 years. The highest seasonal price was always in July during the first period, but it moved back to April and May in the later years.

A dramatic overall change in the pattern of price seasonality occurred over the 24-year period from 1960-84. This movement is best brought out by comparing the average seasonality factors of the first three years, 1960-62, with those of the last three, 1982-84 (Figure 10). The large shifts in the shares of the three rice crops due to the advent of HYVs are visibly reflected in the patterns of seasonality factors in the two periods. In the earlier period, prices started at their lowest in January (the aman season) and rose steadily through July, before retreating with the arrival of the smaller aus and boro crops in August and September.

In recent years, the lowest month has still been January (aman), but the earlier and larger arrivals of aus and boro rice during June-August have caused prices to drop close to their January levels. The direct result for any price stabilization scheme is that careful attention must be paid to both harvest seasons. In addition, the shifts of seasonality are ongoing and require periodic reassessment for policymakers to keep up with their evolution.

Figure 9—Seasonal index, 1960-70 and 1976-84

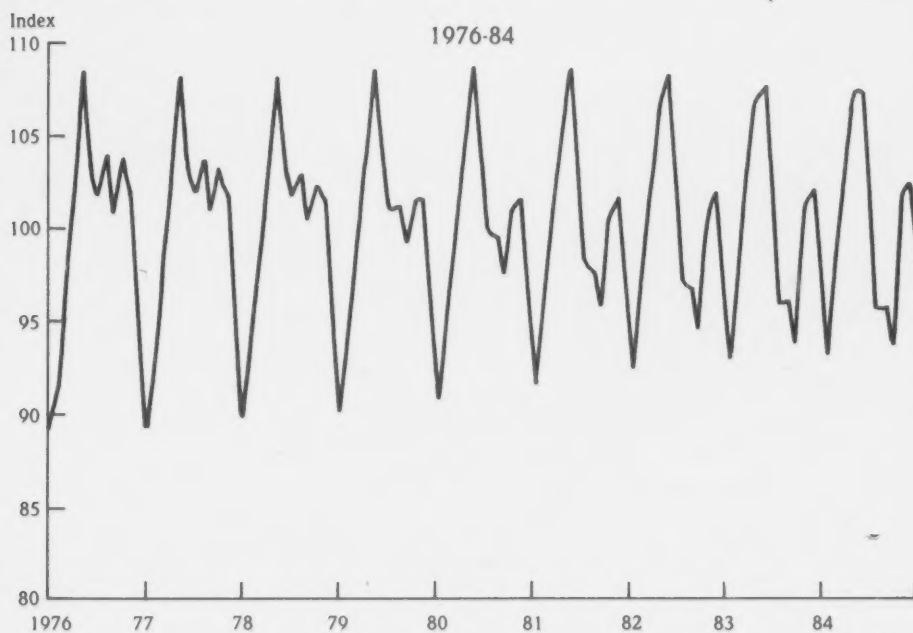
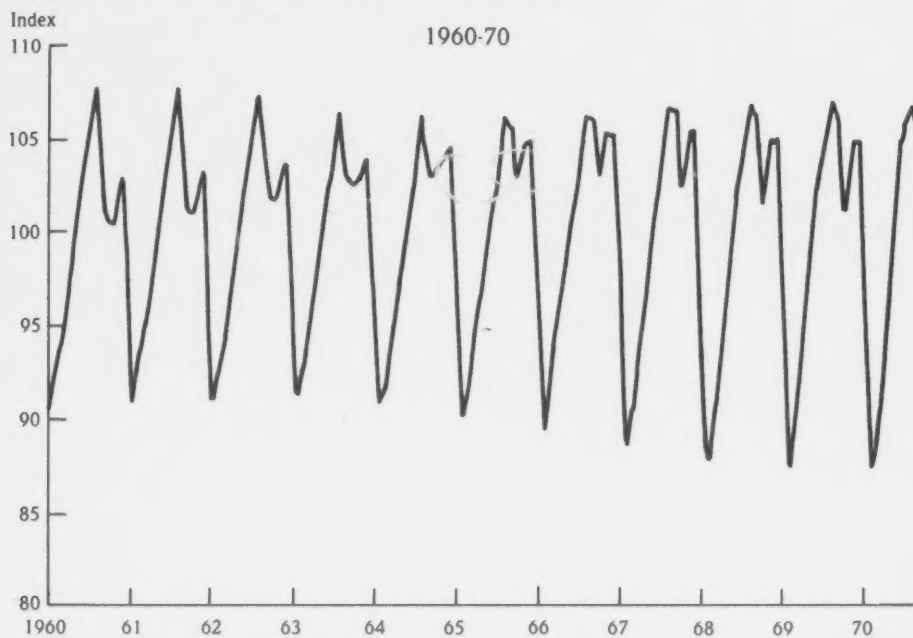
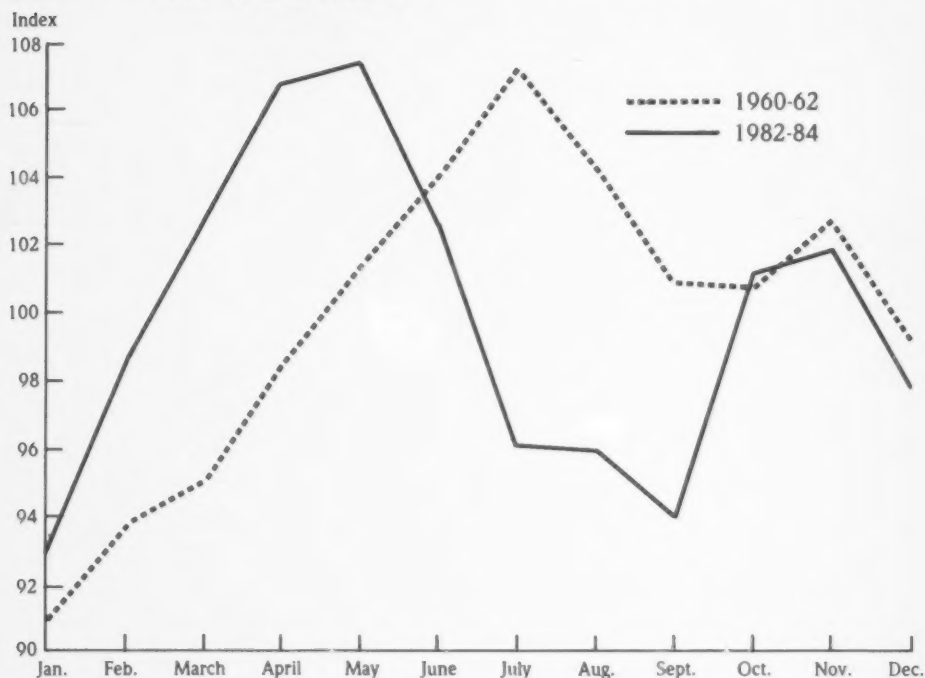


Figure 10—Seasonal factors in rice prices based on three-year averages, 1960-62 and 1982-84



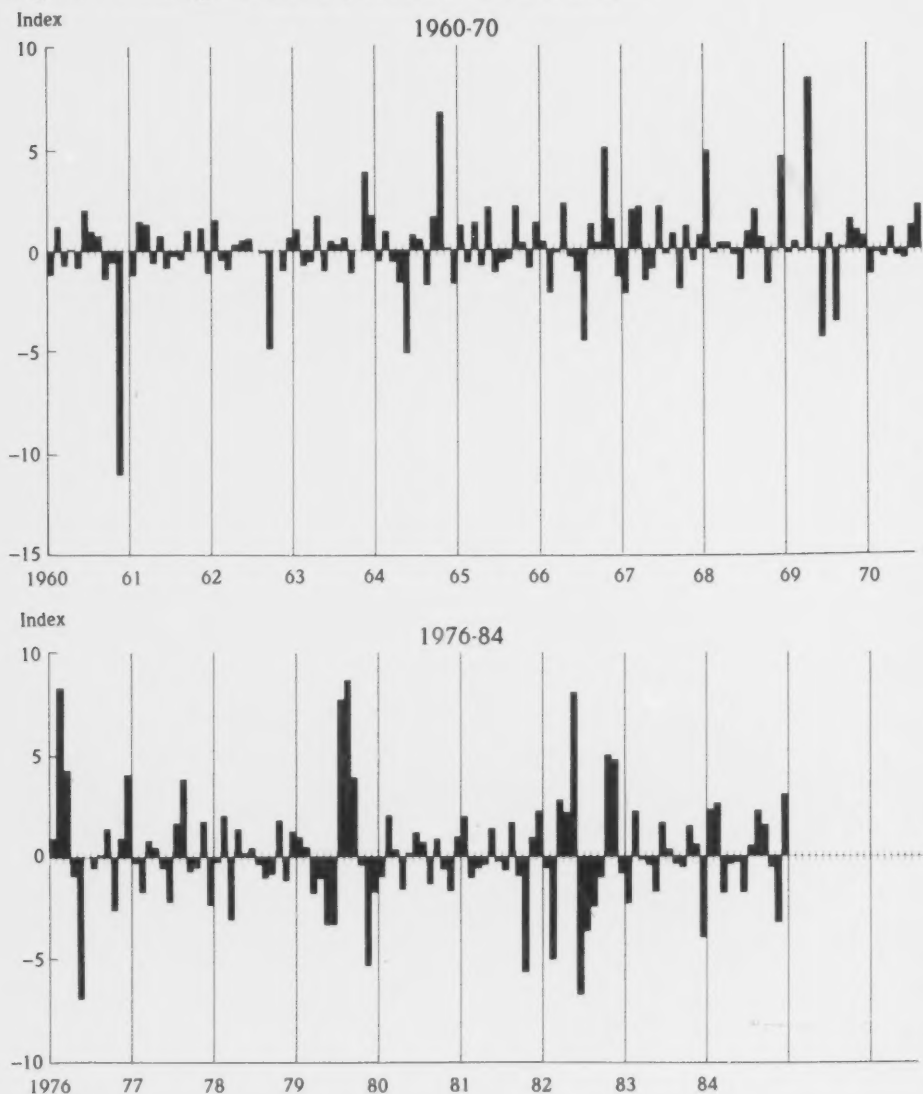
Irregular Factors

Irregular factors represent random effects on prices, generally arising from weather variations but not exclusive of other random phenomena like availability of food aid, war, or erratic public actions. The measurements of irregular factors in the monthly rice prices during 1960-70 and 1976-84 are shown in Figure 11. Comparison of these figures clearly demonstrates that the frequencies as well as amplitudes of irregular factors were much larger during the period 1971-75 relative to either 1960-70 or 1976-84. However, the differences between 1960-70 and 1976-84, the periods of particular interest, are not so obvious. In terms of the number of times when positive or negative deviations of irregular factors exceeded five points, the period 1976-84 appears to be somewhat more volatile than 1960-70. During 1960-70 such deviations occurred in 4 out of 10 years (0.40 per year) compared with 7 in 9 years (0.78 per year) during 1976-84. The 1960s appear to have been relatively blessed compared with either the 1970s or early 1980s.

Integration of Factors

Once the nominal prices have been decomposed into trend, seasonal, and irregular factors, it should be obvious that these can also be integrated to result in the nominal price. This procedure is simple. Trend factors are measured in taka per unit (maund) of rice, whereas seasonal and irregular factors are index numbers based at 100. A multiplicative relation produces this integration as shown in equation (1).

Figure 11—Irregular factors, 1960-70 and 1976-84



Note: The procedure for computing the index is described in Appendix 1.

$$\text{NP} = \text{TR} \cdot \text{SF} \cdot \text{IF}, \quad (1)$$

where

NP = nominal price,
 TR = trend factor,
 SF = seasonal factor, and
 IF = irregular factor.

(See Appendix 2, Table 22, for estimates of these components in 1960 and 1984.)

Perhaps it is appropriate to point out that the pure seasonality pattern as shown earlier is somewhat different from the pattern obtained with the nominal prices. The overall difference, as indicated by the pattern of rising and falling phases of prices, is not, however, so significant as the difference at particular months or phases.

Contribution of Components to Variance in Nominal Prices

The variance and the share contributed by each component—trend, seasonal, and irregular factors—will differ depending on whether one takes the monthly prices, the average of a number of months, or the annual average price. The span of months is therefore a critical factor determining the contribution of the components to the total variance in original data. The shares are presented in Table 8 by time spans in months.

It is clear from the table that in monthly price variations in the original series, the seasonal irregular factors play the dominant role. In the 1960-70 series, the contributions of trend, seasonal, and irregular components to variance of monthly prices are 15, 60, and 23 percent, respectively. These shares in trimonthly prices for the same series are 32, 61, and 7 percent. With the 1976-84 series, the shares of trend, seasonal, and irregular components to variance of monthly prices are 21, 52, and 28 percent. For trimonthly (quarterly) prices these shares change to 47, 44, and 9 percent, respectively, for the 1976-84 series. The significant difference between the two series is reflected in the contribution of the trend-cycle factor in monthly and trimonthly price variations.

Table 8—Relative contribution of components of variance in original series, 1960-70 and 1976-84

Period/ Span in Months	Trend Cycle	Seasonal	Irregular
		(percent)	
1960-70			
1	15.05	59.56	23.39
2	22.53	67.00	10.47
3	31.49	61.31	7.20
4	36.19	59.61	4.20
5	40.53	55.42	4.05
6	46.32	50.74	2.93
7	53.44	44.08	2.48
9	70.06	27.08	2.86
11	90.87	7.15	1.98
12	97.18	0.06	2.76
1976-84			
1	20.49	52.01	27.50
2	33.66	48.24	18.11
3	46.87	43.91	9.22
4	60.02	33.84	6.14
5	70.61	23.84	5.56
6	77.35	18.72	3.94
7	81.32	15.40	3.27
9	85.31	12.06	2.64
11	95.12	3.12	1.76
12	97.40	0.12	2.50

Source: This table is computed from the decomposition analysis of prices discussed in Appendix 1.

The share of the trend-cycle factor in these variations is significantly higher in the 1976-84 series compared with the 1960-70 series. Obviously, the differences in inflationary forces between the two periods resulted in this increased share of the trend factor.

It may be concluded from this analysis that the fluctuations in nominal prices that are observed in contemporary rice markets of Bangladesh are the products of factors reflecting trend and cyclical influences, pure seasonal phenomena, and irregular forces. The pure seasonal factors have changed dramatically with the shift of the peak price month from July in the 1960s to May in the 1980s. Although January remains the lowest price month, a new, second low-price period during August-September has emerged in the posttechnology period (1976-84). This change in pure seasonal factors is frequently masked by the trend and irregular factors that influence nominal prices. The inflationary trend factor together with the irregular factors accentuated the fluctuations in nominal prices during 1976-84 compared with 1960-70. On the other hand, the pure seasonality factors contributed to more stability in prices during the latter period. A cyclical rise and fall in rice prices about every other year became the pattern of the trend-cycle component during 1976-84, whereas there was almost no cyclical movement during 1960-70.

CAUSES OF FLUCTUATIONS IN ANNUAL AND SEASONAL PRICES

The price of rice, like that of any other commodity at a given time and a given market, is determined by the interaction of forces of supply and demand, and the expectations of market actors concerning future prices. The question of time is taken into account by analyzing fluctuations of both annual and seasonal prices. Because there are many markets and because aggregate prices are considered here, it is important to determine whether markets are integrated. This is covered in the next section. Changes in expectations and their effects on price fluctuations are not analyzed in this report (see Ravallion 1985 for such an analysis).

Decomposition Analysis of Annual Price Fluctuations

Domestic production and imports exert supply-side influences, and domestic demand and exports constitute demand-side influences on the price of rice. Foodgrains have rarely been exported from Bangladesh, so domestic consumption is the only demand force. If supply and demand move in the same direction in any year, rice prices will tend to stabilize. If supply and demand move in opposite directions in a given year, rice prices will tend to destabilize. The nature of the interaction of supply and demand forces is therefore considered critical in determining price fluctuations. The Bangladesh economy of the early and mid-1960s was mainly agricultural; the share of agriculture in gross domestic product (GDP) was about 70 percent. The urban population was only about 5 percent of the total. Agricultural income largely represented the basis for demand, and agricultural production largely represented supply. An economic structure of this type implies that supply and demand are jointly determined and move in the same direction, resulting in increased price stability. However, by the early 1980s the supply and demand forces had become more independent. Agriculture contributed only 48.5 percent to total GDP; urban and rural nonfarm populations had increased to more than one-fourth of the total population. These structural changes may have contributed to increased price instability, while government policies on foodgrain imports may have mitigated any deleterious effects from the separation of demand and supply. To examine these hypotheses, the following formal model is used.

The Model

The methodology in this exercise uses a simple supply and demand equilibrium model to decompose price variance. The formal version is as follows:

$$Q_d = a - bP_t, \quad (2)$$

$$Q_s = c + dP_t, \quad (3)$$

$$Q_i = e, \text{ and} \quad (4)$$

$$Q_d = Q_s + Q_i, \quad (5)$$

where a is the demand intercept, c is the supply intercept, e is the import intercept, and b and d are the slope parameters. Imports are determined independently of domestic price, so equation (4) has no slope parameters. Attempts to fit an equation of imports on domestic and world prices show no significant relations. Whereas policy may use an expected price in deciding about imports, delays in arrivals or other aid-related factors obscure relations in past data. It should be noted here that while many exogenous factors (income, wealth, and so forth) influence prices and quantities in this system, the model conveniently reduces them to net intercept terms in order to greatly reduce data and computational needs. Given the objectives of examining the effect on price variance of broad forces of supply and demand, such a simplified model is appropriate.

This structural model, which was employed first by Piggot (1978, 1986), is then loosened somewhat by equating the slope parameters with the elasticities evaluated at the means (following Myers and Runge 1985), resulting in

$$b = \varepsilon_d \cdot (q/p), \text{ and} \quad (6)$$

$$d = \varepsilon_s \cdot (q/p), \quad (7)$$

where ε_d is the elasticity of demand and ε_s is the elasticity of supply.

The constants are finally derived as

$$a = Q_d + bPt, \quad (8)$$

$$c = Q_s - dPt, \text{ and} \quad (9)$$

$$e = Qi. \quad (10)$$

In matrix notation the system of equations (2) through (5) can be written:

$$AY = C, \quad (11)$$

where A is a matrix of coefficients associated with the endogenous variables (price and quantity), Y is a matrix of endogenous variables, and C is a matrix of net intercepts.

The variance-covariance matrix of the endogenous variables is

$$T = xv'x', \quad (12)$$

where

T = the desired variance-covariance matrix,

$x = A^{-1}$,

v = the variance-covariance matrix of the net intercepts, and

x' = the inverse of x .

From this form the composite elements of variance directly attributable to demand, supply, and import intercepts and their interactions can be easily identified. The contributions of demand for and imports of domestic products and their interactions with the variance of prices are measured for the 1961-70 and 1975-84 periods. The price elasticity of demand is assumed to be -0.4 , and the price elasticity of supply is allowed to vary from 0.2 to 0.4 , particularly to accommodate the situation in the second period. Most cross-section and time series estimates of price elasticity of demand center around -0.4 (Ahmed 1981, Pitt 1983).

Results

The contributions to the total price variance of the six components—demand, production, imports, interaction of demand and production, interaction of demand and imports, and interaction of production and imports—are shown in Table 9. These contributions change dramatically between the first and second time periods. The first decade is characterized by large, positive, direct effects of domestic production and demand and a comparably large, negative interaction term. Over the range of results, imports play a small role. As Myers and Runge (1985) found in their analysis of the U.S. maize market, this large interaction term is the result of the simultaneous shifting

Table 9—Decomposition of price variability, 1961-70 and 1974-83

Variable	Percent of Price Variance Explained		Ratio of Demand/Net Supply Effects	
	1961-70	1974-83	1961-70	1974-83
	(percent)			
$\epsilon_s = 0.20$				
Demand	305	60	1.05	1.17
Demand/supply interaction	-486	35		
Demand/import interaction	-1	-35		
Supply	289	44		
Supply/import interaction	-9	-10		
Imports	2	7		
Total	100	100		
$\epsilon_s = 0.25$				
Demand	261	51	1.02	0.98
Demand/supply interaction	-406	38		
Demand/import interaction	-1	-30		
Supply	253	46		
Supply/import interaction	-8	-11		
Imports	2	6		
Total	100	100		
$\epsilon_s = 0.30$				
Demand	225	45	0.99	0.85
Demand/supply interaction	-343	40		
Demand/import interaction	-1	-26		
Supply	225	48		
Supply/import interaction	-8	-11		
Imports	2	5		
Total	100	100		
$\epsilon_s = 0.35$				
Demand	196	39	0.96	0.74
Demand/supply interaction	-293	41		
Demand/import interaction	-1	-23		
Supply	203	49		
Supply/import interaction	-7	-11		
Imports	2	4		
Total	100	100		
$\epsilon_s = 0.40$				
Demand	173	35	0.93	0.64
Demand/supply interaction	-252	42		
Demand/import interaction	-1	-20		
Supply	185	51		
Supply/import interaction	-6	-12		
Imports	1	4		
Total	100	100		

Note: Numbers may not add to total because of rounding. The demand elasticity is $\epsilon_d = -0.4$, and the supply elasticities (ϵ_s) are given in the table.

of supply and demand curves, hypothesized earlier in this section. This study suggests that the shifts are outward movements of both curves.

The characteristics of the second time period are quite different. The direct demand and domestic production components are remarkably smaller, and more important, their interaction terms have switched signs. No longer are the curves shifting in the same direction, and no longer is the price being stabilized by the interaction of supply and demand. The hypothesis that supply and demand forces have become more independent in the second time period is reinforced by these results.

The effect of imports has increased strongly in the later decade. The demand-import covariances are always negative, as are those of domestic production and imports, and they largely offset the positive production-demand covariances. Thus a fundamental shift in the overall structure of price variability has occurred between the two periods. In the latter time period, at almost every level of supply elasticity, the contribution of supply variability to price variability is higher than that of demand. More important, if the supply elasticity increases between periods (as is hypothesized for the advent of the new rice technology), then the shift is more dramatic. During the 1960s the contributions of supply and demand forces were almost equal to price variation. In the late 1970s and early 1980s supply variability became the dominant force behind price fluctuations.

Even though changes in supply elasticity make a difference in the results, they do not influence the conclusions concerning imports. At all levels of elasticity, imports became more important in overall price variance in the second period. Especially noteworthy are the large negative covariances: imports helped to offset shortfalls in supply and increases in demand.

The foregoing conclusions are important to the analysis of contemporary policies in price stabilization. In attempting to derive lessons for current policy purposes, a straightforward comparison of policies in the 1960s and those practiced now may be hazardous unless this structural change in demand-supply relations is kept in view. On the domestic front, the major sources of price instability are the weather factors that affect production. Forecasting domestic production under the influence of randomly occurring weather disturbances has assumed an added importance in a structural situation where demand and supply forces are becoming more and more independent. In this context, a brief analysis of the effects of flood and drought on variability of production is quite revealing.

Random Effects of Flood and Drought

Earlier it was shown that extremely irregular fluctuations in prices were more frequent in 1976-84 than in 1960-70. Government efforts to stabilize prices were more intensive in the later than in the earlier period. During 1976-84, domestic procurement of foodgrains as a price support measure reached half a million tons (equivalent to 25 to 40 percent of marketed surplus) in good production years. Open market sales from public stock during poor harvest years were also introduced during this period. Neither procurement for price support nor open market sales were effectively employed to stabilize prices in 1960-70. However, erratic behavior of public purchases, imports, and sales may aggravate rather than pacify instability in prices. This happens primarily because of the misreading of the effects of natural calamity when the government responds vigorously to counteract the effects of floods, droughts, and cyclones with excessive or inadequate imports of foodgrains.

An accurate assessment of crop damages from natural disasters is therefore crucial

for combating erratic movements in foodgrain prices. The government has an established procedure and mechanism for assessing crop damages from natural calamities.² Table 10 gives a picture of the size of the loss in production of rice crops due to flood and cyclone. Although these statistics are less reliable than crop production estimates, the relative intensity of the adverse effects of flood and cyclone in various years is reflected. The estimates of crop loss from drought are not available. It is difficult to assess loss from drought because such damages are often intricately enmeshed with land productivity and various factors that influence this productivity. Unlike flood damage, drought loss cannot be easily identified and measured, except when farmers fail to sow or plant because of drought. Nevertheless, loss from drought is likely to be more severe than that from flood in Bangladesh.

The data in Table 10 show that flood damage is more frequent than cyclone damage, and aus and aman rice crops are more vulnerable to flood than boro. However, as more areas are sown with HYVs, the proportion of HYV crop loss due to flood appears to be larger than the overall proportion of HYVs in total rice-cropped area. While the share of HYVs in total rice-cropped area ranged from 19 to 24 percent during 1979/80-1983/84, the share of the HYV crop lost to flood appears to range from 31 to 50 percent of total rice losses in the same period. The capacity of HYVs to overcome short-duration flooding and drought is generally much weaker than that of local varieties. The interaction of HYVs and natural calamity thus increases instability in production and prices. The estimates of loss of production from flooding, as presented in Table 10, are in

Table 10—Loss of rice production from floods and cyclones, 1969-84

Calendar Year	Total Loss	Share of Aus in Total Loss	Share of Aman in Total Loss	Share of Boro in Total Loss	Share of HYVs in Total Loss	Share Lost from Floods	Share Lost from Cyclones
	(1,000 metric tons)				(percent)		
1969	218.08	15.2	83.7	1.1	0.9	100.0	0.0
1970	1,411.95	13.8	86.0	0.1	0.1	47.1	52.9
1971	305.27	18.0	82.0	0.0	6.0	100.0	0.0
1972	244.82	30.0	70.0	0.0	0.2	100.0	0.0
1973	895.15	22.2	77.8	0.0	13.0	67.8	32.2
1974	535.41	43.5	56.5	0.0	13.3	100.0	0.0
1975	279.57	24.2	9.0	66.8	25.6	100.0	0.0
1976	681.85	51.5	38.7	9.8	31.7	100.0	0.0
1977	402.33	3.6	14.3	82.1	27.5	17.8	82.2
1978	131.12	49.7	24.6	25.7	39.8	99.7	0.3
1979	60.47	22.3	77.7	0.0	12.2	100.0	0.0
1980	285.05	10.4	88.1	1.5	40.5	100.0	0.0
1981	158.90	33.8	13.0	53.2	47.3	100.0	0.0
1982	175.22	25.2	53.8	21.0	42.2	100.0	0.0
1983	540.15	28.1	45.9	25.0	50.3	100.0	0.0
1984	1,949.17	16.2	4.7	19.1	30.5	100.0	0.0

Sources: Computed from Bangladesh, Bureau of Statistics, *Agricultural Yearbook 1979-80* (Dhaka: BBS, 1981); and Bangladesh, Bureau of Statistics, *Statistical Yearbook of Bangladesh, 1985* (Dhaka: BBS, 1986).

² In the event of a natural calamity, the government's agriculture extension workers and statistical assistants at the *upazila* and *union* administrative levels are asked to assess the extent of damages in planted areas and yields of various crops in the afflicted zones. This information is examined and aggregated at various levels before final aggregation at the national levels.

calendar years. These estimates are rearranged into fiscal years to compare them with the annual official statistics of rice production, which are available in fiscal years in Table 11. Some interesting lessons on relative adverse effects of flooding and droughts clearly emerge from this data. First, in almost all years with moderate to severe flooding (crop loss of more than 300,000 tons)³ but with no severe drought, actual production of rice has remained above trend production. This supports the hypothesis that location-specific flood losses do not lead to an aggregate loss of crop production by the same amount. Flooding causes locational income and employment problems, but it does not adversely affect, and may even improve aggregate supply and hence average prices.⁴ Flooding is caused by excessive rainfall, which may cause crop damage in low-lying areas but at the same time improves soil moisture and crop yields in highland rice crops. In most flood years, the average actual yields are higher than trend yields. Montgomery (1985) arrived at similar conclusions in his analysis of the effects of flooding in Bangladesh.

Second, the impact on aggregate production becomes most serious when severe floods and droughts occur in the same year. Third, a severe drought, even without a severe or moderate flood, is often found to cause actual aggregate production to fall below trend production. Thus, drought is more menacing than flood in Bangladesh as far as aggregate production is concerned.

Causal Analysis of Seasonal Price Fluctuations

In analyzing the factors that explain the pattern of seasonality in prices, particular emphasis is placed on new technology and on storage costs.

Storage Costs and Seasonal Prices

If traders in a competitive market always knew in advance what the peak price would be in the upcoming season, and if they did not have any capital constraint, then they would purchase and store as much rice in the harvest season as they would be able to sell in the peak price season to maximize total profit. This would be possible only if the storage cost, including a normal profit, is accommodated within the price gap between harvest and peak seasons. In this situation the seasonal factor—that is, the price spread between the two seasons—would be equal to the storage cost. But the reality will certainly be different. The peak price cannot be foreseen with certainty; only a speculative guess based on current information is possible. The market may not be competitive, particularly if capital is constrained. Therefore, in any particular trading period, seasonal price spreads are likely to deviate from the storage cost. But over a number of trading periods, the average price spread would tend to be equal to the storage cost, implying that excess profits in some periods compensate for losses in others.

In the context of developing market economies, the storage cost is something that cannot be identified with the prevailing interest rates in the organized financial markets. In such countries the storage function is performed by farmers, full-time traders, and government. Farmers in Bangladesh store about a quarter of the marketable surplus of rice, although precise estimates are hard to find (Bangladesh, Bureau of Statistics 1968).

³ All tons in this report are metric tons.

⁴ The classic case was the 1976/77 cyclone and flood damage, which was largely limited to the district of Sylhet, where the government had to take special measures to support income and employment of the poor even though the national average price in that year was lower than the previous year.

Table 11—Relative adverse effects of flood and drought on production of rice, 1969/70 to 1983/84

Fiscal Years ^a	Flood Loss	Deviation of Production from Trend	Deviation of Yield Rate from Trend	Deviation of Area Planted from Trend	Recorded Drought Status
	(1,000 metric tons)		(ton/acre)	(1,000 acres)	
1969/70	218.14	1,488.60	0.0313	1,531.73	...
1970/71	1,409.58	375.40	0.0070	402.99	...
1971/72 ^b	305.27	-1,082.80	-0.0218	-1,302.75	...
1972/73	244.82	-1,191.00	-0.0388	-568.50	Severe
1973/74	895.15	333.80	0.0161	-91.24	...
1974/75	722.26	-543.40	-0.0129	440.98	Severe
1975/76	159.63	643.40	0.0121	750.28	...
1976/77	945.58	-615.80	-0.0142	-492.47	Moderate
1977/78	109.54	316.00	0.0193	-270.21	...
1978/79	97.45	-67.20	0.0021	-192.95	...
1979/80	64.60	-439.40	-0.0123	-215.70	Severe
1980/81	365.44	419.40	0.0166	16.56	...
1981/82	95.37	-93.80	-0.0086	250.82	Severe
1982/83	180.11	217.00	-0.0007	427.07	...
1983/84	590.02	239.80	0.0043	195.33	...

Sources: Computed from flood loss statistics in Bangladesh, Bureau of Statistics, *Statistical Yearbook* (Dhaka: BBS, 1986) and Bangladesh, Bureau of Statistics, *Agricultural Yearbook 1979/80* (Dhaka: BBS, 1981).

^a When crop losses are rearranged from crop years to fiscal years, the following adjustments are made: the figures for aus and aman rice in crop year 1969 and those for boro in crop year 1970 constitute the total for the fiscal year 1969/70.

^b This is the year of civil war in Bangladesh when about 3 million people died, resulting in large-scale failure to plant or sow rice crops.

The storage cost and possible benefit at the farm level is dependent on a host of factors including conditions in the informal credit market and food security considerations. The informal credit market is highly fragmented and restricted in scope, and the implicit interest rate in these markets is often quite high. An interest rate in excess of 50 percent per year is not uncommon. But this does not mean that everybody can lend money at that rate. In fact, a large majority of farmers with surplus financial resources cannot find opportunities for investment in informal credit markets. Therefore, the market is limited to friends and relatives and to those who can ensure a credit discipline and loan security of various forms (such as a land mortgage or sales contract for commodities or assets). Some farmers also hold stock for reasons of food security. They delay sale of surplus stock from the current harvest until it becomes clear that the next harvest is going to provide an adequate supply for the next consumption period. Of course, distress sales occasionally override this food security consideration, but such sales are generally a small fraction of total sales.⁵

Theoretically, organized commercial banks in rural areas can provide an alternative opportunity to surplus farmers for investment, and the interest rate in these banks can serve as a basis for estimating the storage cost of farm stockholders. In fact, establishment of commercial banking has progressed in Bangladesh so that almost all *upazilas* (administrative units of about 100 villages) do have a bank. But corruption, illiteracy, lack of

⁵ Part of the distress sale figure may also be the result of inadequate physical storage facilities on farms, particularly among small farmers with poor housing.

banking tradition, and interest rate policies of these banks have kept the effective use of these institutions from spreading among the majority of farmers.

The second category of rice stockholder, the government, purchases rice from farmers, generally in the aman season. This rice and imported grains constitute the two sources of government stock. Storage cost plays a small role in the decisions of the government in fixing the harvest-season procurement price and the peak-season sale price. The government's share in the total marketable surplus varies tremendously across years. In several years of the period 1970-84 this share was as high as 30-40 percent, while in most years it ranged from 2-10 percent of marketable surplus.⁶

The third category, the full-time traders in rice, are the stockholders in the free market who share the remaining portion of marketable surplus. Their storage costs might be approximated by the interest rate in the organized financial markets, but most of the traders conduct trade based on their own capital, which may have a different opportunity cost than the market interest rate. The interest rate in commercial banks for short-term borrowing was about 4 percent during 1964/65 when the general rate of inflation was also about 4 percent. In 1983/84, similar borrowing from banks cost an interest rate of about 15-16 percent with an inflation rate of about 14 percent. The real rate of interest in commercial banks therefore does not appear to have changed much. On the face of it, one would expect that real storage costs and resulting seasonality in prices would also be stable during the early 1960s and the early 1980s. But the storage cost between the two periods could be different even if the real interest rate were the same because of the difference in the length of storage brought about by new technology.

New Technology, Rice Production, and Seasonal Prices

The new rice varieties (HYVs) have had a significant effect on growth in foodgrain production in Bangladesh. The trend growth rates were not significantly different between the periods 1960-70, 3.1 percent a year, and 1971-84, 2.9 percent a year. The growth rate was faster (about 3.6 percent) during 1975-84 than in any other period. However, the sources of growth between the 1960s and the post-1970 period were remarkably different.

The increase in acreage was the main source of growth during 1960-70, whereas improvement in productivity of land was the primary source during 1971-84. The share of acreage in the incremental production of rice during 1960-70 was 57.4 percent, and the share of yield was 31.6 percent. This pattern changed drastically so that the share of acreage was only 14.3 percent and that of yield was 69.2 percent during 1971-84 (Hossain 1984). That new technology in agriculture brought about this phenomenal change is supported by information in Table 12 and related to statistics on the use of modern inputs in agriculture (Table 13). The most striking feature of the changing pattern of rice production in Bangladesh is the increase in the average share of HYVs, which has risen from zero in 1960-62 to about 42 percent in 1982-84.

Three consequences of this technological progress in rice production are important for the seasonal pattern of rice prices. First, assuming that aus, aman, and boro rice come to the market within a certain time period after harvest, and this timing has not been changed by technology, one would expect the increased production and hence

⁶ These estimates are based on the quantities procured by the government in various years and on the estimates of gross marketable surplus determined by relating such surplus to gross production, as formulated in Ahmed (1981).

Table 12—Changes in the shares of different rice crops in total rice output, 1960-62, 1969-70, and 1982-84

Rice Crops	1960-62	1969-70	1982-84
		(percent)	
Aus local	25.42	24.63	15.13
Aus HYV	0.00	0.70	6.77
Aus total	25.42	25.33	21.90
Aman local	69.67	55.78	39.75
Aman HYV	0.00	1.08	14.37
Aman total	69.67	56.86	54.12
Boro local	4.91	8.91	3.60
Boro HYV	0.00	8.90	20.38
Boro total	4.91	17.81	23.98
All rice	100.00	100.00	100.00
All HYVs	0.00	10.68	41.52

Sources: Bangladesh, Bureau of Statistics, *Statistical Abstract of East Pakistan* (Dhaka: BBS, 1966); and Bangladesh, Bureau of Statistics, *Statistical Yearbook of Bangladesh, 1985* (Dhaka: BBS, 1986).

market supply to generate different degrees of downward pressure on market prices at different seasons, all else being the same. This is so because the effects of technology are quite different in different types (or seasons) of rice, as is clearly shown in Table 12. In comparing the shares of various types of rice in total rice output between 1960-62 and 1982-84, the table demonstrates that the share of boro rice has risen from about 5 percent to 24 percent, the share of aus rice has fallen moderately from 25 to 22 percent, but the share of aman rice has declined sharply from about 70 percent to 54 percent. Moreover, the production of early-harvested broadcast aman has dwindled, shortening the length of the aman harvest period. Of the 24 percent share of boro rice in 1982-84, a little more than 20 percent was HYV boro. HYV aus accounted for only 7 percent, and HYV aman accounted for 14 percent of total rice production in 1982-84.

Table 13—Trend in the use of modern agricultural inputs, 1960/61-1983/84

Years	Area Irrigated by Modern Methods	HYV Area	Use of Chemical Fertilizers
	(percent of net cultivated area)	(percent of cropped area)	(nutrient pounds/ cropped area) ^a
1960/61	0.3	...	2
1965/66	0.9	...	4
1969/70	2.6	2.1	9
1975/76	7.7	13.0	15
1977/78	9.4	13.4	24
1979/80	12.8	18.8	28
1980/81	13.6	21.0	28
1982/83	19.2	22.9	31
1983/84	20.3	23.6	36

Source: Mahabub Hossain, "Agricultural Development in Bangladesh: A Historical Perspective," *Bangladesh Development Studies* 12 (No. 4, 1984): p. 12.

Note: The ellipses indicate a nil or negligible amount.

^a The trend in the use of absolute quantities of fertilizers rises much faster than the use per cropped acre because of increased cropping intensity.

Second, the technological progress in rice cultivation has brought in its wake changes in the timing of planting, average growth period, and harvest of various rice crops. Therefore, the timing of market arrivals of harvested crops has also changed, with consequent effects on seasonality of prices. The time of harvest varies slightly among districts due to agroclimatic conditions; the average harvest time is that time when the major portion of the crop is harvested. The average harvest times of various rice types during 1960-62 and 1982-84 in the country as a whole are shown in Table 14.

Since market arrivals begin only two to four weeks after harvest, it is not difficult to unravel the source of shift in seasonal prices of rice, as shown in Figure 10. As a result of the new technology the second-lowest price level now occurs in September because the boro and aus harvests overlap somewhat during the month of August. This overlapping occurs because of the staggering of the boro harvests over two months. The delayed planting of the irrigation-based boro crop, which is sown on new land at higher elevations, is partly the cause. Moreover, the growth period of the new HYVs is about 30-40 days longer than that of the local varieties (Bangladesh Agricultural Research Council 1983, 1982). As the harvests of boro and aus have moved forward by about two months without any substantial change in the harvest period of aman, the peak price season has become the month of May in the posttechnology period compared with a peak price period around July during the pretechnology era. During the earlier period, boro was a much smaller crop than now, which is also reflected in the July peak.

Third, and closely related, is the question of storability of different types of rice, and the effect of storability on the seasonal pattern of prices. Aus rice is harvested in wet months, and its moisture content is generally high. Farmers find it difficult to dry aus rice sufficiently. The same can be said but to a lesser degree of HYV boro. The storability of local boro is moderately good to excellent. Because aman varieties are harvested in dry stalks, they have excellent storability. For this reason, as well as taste, farmers with a surplus tend to sell their HYV and aus rice and to keep the aman rice for home consumption and for sale in a later month when prices are higher. These factors also contribute to the peak price situation around the month of May and a second low price period just after harvest of aus and boro.

Relation Between Seasonality in Prices and Production

The discussion of seasonality of prices and its causal factors has been predominantly descriptive. To understand the process better and to appreciate the weights of various

Table 14—Harvest months for various types of rice, 1960-62 and 1982-84

Type of Rice	1960-62	1982-84
Local aus	July-August	July-August
HYV aus	...	August-September
Local transplanted aman	December-January	December-January
HYV aman	...	January-February
Broadcast aman	November-December	November-December
Local boro	April-May	April-May
HYV boro	...	June-July

Sources: The information for 1960-62 is based on Bangladesh, Bureau of Statistics, *Surplus Labour in Paddy Cultivation in East Pakistan, 1964/65* (Dhaka: BBS, 1965). The information for 1982-84 is based on various sample surveys for crop estimates of the Bureau of Statistics and on field surveys by the Bangladesh Rice Research Institute.

causal factors that may have potential as policy instruments, it would be desirable to translate the descriptive points to objective measures. Unfortunately, lack of appropriate, season-specific data frustrates attempts to make a comprehensive objective analysis of seasonality.

A theoretically consistent approach to conducting a causal analysis of seasonality would require data on both demand and supply determinants by seasons, including some variables or specifications that could account for traders' expectation of prices. However, season-specific information on income, procurement, public distribution, prices of substitutes, and market arrivals from domestic production is not available. The only available season-specific data expected to have an important influence on seasonality of prices are for production. Thus, aman, aus, and boro rice harvests may be treated as proxies of seasonal supply. A regression model relating the measure of fluctuation in seasonal prices with seasonal production is undoubtedly an underspecification of the causal relation. Nevertheless, an estimate of this relation is provided here in order to reinforce the common understanding that the pattern of seasonal production significantly influences seasonality in prices. The estimate of the equation is

$$\begin{aligned} \log S = 24.67 - 2.65 \log AMN + 0.73 \log BORAS; \\ (1.23)(-1.06) \quad (0.76) \\ \bar{R}^2 = 0.12, \end{aligned} \quad (13)$$

where S is the measure of seasonal fluctuations. S is measured by the difference of peak and trough seasonal prices after nominal prices are adjusted for the trend-cycle component. Therefore, it represents the band or amplitude of the pure seasonal and irregular factors of prices. AMN is the aman harvest and $BORAS$ is the sum of boro and aus harvests, which have overlapped for a short time in recent years. The t -values are in parentheses. The analysis covers 1976-84.

Although the explanatory power of the influence is weak ($\bar{R}^2 = 0.12$), and the level of significance of the coefficients is also poor, the direction of the relation may be of some value. On this basis, it can be concluded that an increase in aman production in any year reduces the band of seasonal prices, and the increase in the combined boro and aus production widens the band of seasonal prices. This result seems consistent with the earlier finding that the effects of seasonality were accentuated in 1976-84 compared with 1960-70. During 1976-84, the share of aman declined and the share of aus plus boro increased compared with their respective shares in 1960-70.

Quantitative analysis of factors causing seasonal variation in prices and measurement of the weights of each of these factors on seasonality remains an underexploited area of investigation. Systematic development of seasonal information will be a first requirement for conduct of such analyses in the future.

In summary, the relative independence of supply and demand factors, accompanied by inelastic supply and demand elasticities, has increased annual price variability during recent years. Supply factors and their interactions with imports have become more dominant in explaining fluctuation in annual prices. These developments imply that an accurate forecast of domestic production is a critical requirement for planning price stabilization measures, including the need for imports. New technology has not accentuated the underlying pure seasonality of prices, although random fluctuation in seasonal prices has increased in recent years. All these factors dictate that price stabilization should be organized on a more systematic basis than in the past.

INTERMARKET LINKS AND REGIONAL PRICES

As mentioned in the introduction, an examination of the strength of integration among the many spatially distributed markets that constitute the basis of aggregate price analysis may identify weaker links in the chain of markets, which then can be kept under special purview when price stabilization measures are implemented. Segmentation of markets, that is, a complete lack of integration, implies that a market with excess demand does not get feedback from another market with excess supply. Therefore, the transmission of prices between such markets is absent. Markets may not be segmented, however, but the degree of integration or the rapidity and extent of transmission of prices among markets may still be weak for technical and economic reasons (for example, monsoons, political strikes, or high transaction costs in trade). Market integration does not mean that prices across geographical regions should be the same. Intermarket price differences will exist because of differences in transportation costs. These differences should not impair the transmission of price signals and trade among markets. In this chapter most regional rice markets in Bangladesh are shown to be integrated. Therefore, the adoption of an aggregate approach in modeling the price stabilization program is appropriate. But, even though the overall integration of markets is evident, there are occasions and locations where market integration is weaker than normal.

Regional Price Differentials

The trade flow in rice generally follows the pattern of supply from the hinterlands to the main industrial and urban centers of Dhaka, Chittagong, and Khulna. In addition, deficit districts receive supplies from nearby surplus districts. On the basis of this pattern of trade flow, the price differentials between markets, reflecting the marketing margins in interregional trade, are estimated for aus and aman rice. The price differential is calculated as

$$(P_1 - P_2)/P_1, \quad (14)$$

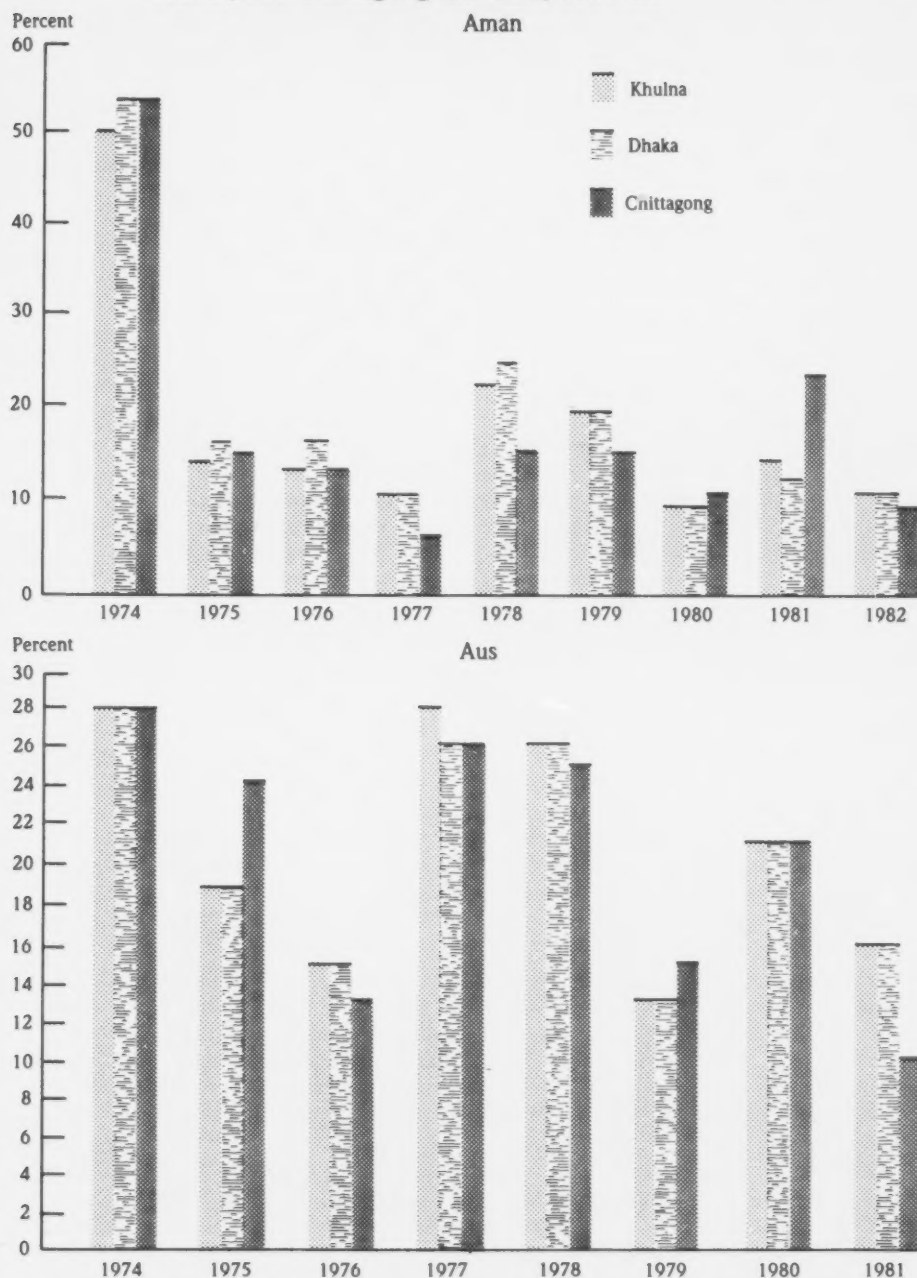
where P_1 is the price at the first market in a given year, and P_2 is the price at the second market in the same year.

The estimates of price spreads or spatial marketing margins vary considerably by region and by time. However, there is no guarantee that the pairs of markets with high marketing margins necessarily constitute trade channels with any substantial volume of trade. For example, the Dinajpur-Noakhali channel exhibits an average price differential of 22 percent with a standard deviation of 33 percent, but trade in this channel is infrequent and small.

This information is summarized graphically in Figure 12. The graph shows the difference between highest and lowest prices in the Dhaka, Khulna, and Chittagong divisions, expressed as a percentage of the highest price. A number of conclusions can be derived from this information.

Spatial price differences average about 15 percent in aman rice and 18 percent in aus rice, but this average proportion varies in different years. In 1974, the proportion

Figure 12—Intraregional price spreads for aman and aus rice in Khulna, Dhaka, and Chittagong divisions, 1974-82



Source: Computed from price data in Bangladesh Bureau of Statistics, *Statistical Yearbook, 1983/84* (Dhaka: BBS, 1985); and Bangladesh Bureau of Statistics, *Statistical Yearbook, 1985/86* (Dhaka: BBS, 1987).

rose to about 50 percent in aman and 28 percent in aus rice. Prices rose abnormally in 1974, particularly in the aman season. Recovery from disruptions in the market related to the civil war of 1972, particularly those involving movement of market functionaries, did not come about until that year. Even excluding 1974, spatial price margins appear to rise proportionately faster in years of rising prices.

This last point, that the proportion of the marketing margin rises with the rise in price levels, implies that either marketing costs increase with the rise in prices or traders reap an above-normal profit during such times. Perhaps the latter explanation is more realistic, and this may be the reason why policymakers distrust traders during periods of rising prices. However, such a phenomenon may not be irrational or an act of exploitation by traders if the relation between the marketing margin and level of prices is symmetrical. In that event, traders would make subnormal profits during a phase of falling prices, offset by above-normal profits during a phase of rising prices.

Methodological approaches to investigate the extent of market integration were initially limited to simple price correlations between markets. That such correlations are not always a proper indicator for market integration is evident from studies by Jones (1976), Harriss (1979), and Timmer (1974). Common factors like inflation, seasonality, and consistent price setting by public agencies may generate high correlation coefficients among market prices even though the underlying conditions are not congenial to an integrated market. Nevertheless, the correlation coefficients are not entirely meaningless. If the correlation coefficient between one pair of markets is higher than that for another pair, both operating under the same set of factors, obviously the former pair is more integrated than the latter. Therefore, the nature of integration in rice markets in Bangladesh is examined first through simple correlations and then through a somewhat more sophisticated approach suggested in recent literature (Ravallion 1986, Heytens 1986).

Interdistrict Correlations of Monthly Rice Prices

The paired correlation coefficients between district average prices of aman and aus rice are shown in Appendix 2, Tables 23 and 24. Price correlations during a period of rapidly changing prices could be different from those during a period of relatively stable prices. For this reason the correlation coefficients in stable and unstable years are worked out separately. In general, there is no difference in the number of significant coefficients between the stable and unstable years (years with less than or more than a 10 percent change in prices). However, the absolute magnitudes of correlation coefficients are slightly higher in unstable years. Only the coefficients for unstable years are presented in the tables. The locations of districts are shown in the map of Bangladesh (Figure 13).

The immediate observation that emerges from the correlation coefficients is that, measured by this indicator, aus rice markets are well integrated. Only 48 out of 190 pairs of correlations (about 25 percent) are statistically insignificant; all remaining coefficients are highly significant. Of the 48 insignificant coefficients, 18 relate Chittagong to other districts in the northern and southern parts of Bangladesh. Chittagong is one of the largest aus-growing districts. However, its transportation connections with districts in northern and southern Bangladesh are not well developed, inhibiting rice flows and perhaps causing insignificant correlations. Chittagong aus prices may need special monitoring during implementation of any stabilization scheme.

In the case of the aman price, there are 63 out of 190 pairs of correlations that are statistically insignificant. On this score, aman rice markets may appear to be less

Figure 13—Map of Bangladesh



integrated than aus. However, 51 out of the 63 insignificant correlations in aman prices pertain to Barisal, Patuakhali, Dinajpur, and Bogra. The first three are extremely backward in infrastructural development. Moreover, these districts again have larger shares of aman production than other districts. Therefore, concentration of production and backward infrastructure may be associated with disharmony in price movements between these three and the other rice markets of Bangladesh.

Application of an Advanced Test of Market Integration

Methodological developments for studying market integration are quite sparse. Ravallion (1986) developed a general approach to modeling market integration that can estimate the extent to which local prices are influenced by prices elsewhere. He employed this model with rice prices in Bangladesh just prior to and during the 1974 famine. His test of segmentation in rice markets rejected the hypothesis of segmented markets, but the test on short-run integration of markets was inconclusive. It must be noted that Ravallion's inquiry covered not only a period when a famine was raging in Bangladesh, but also a period just following a civil war when the country was still trying to recover from the infrastructural destruction wrought by that war. Ravallion's model has also been empirically applied by Heytens (1986) on Nigerian data. Timmer (1974) proposed a further use of the parameters from Ravallion's model to construct some indicators that will be explained later.

The Model

The estimating equation that was derived from Ravallion's general approach and used for the present study closely follows Heytens' discussion.

$$(P_{it} - P_{it-1}) = (\alpha_i - 1)(P_{it-1} - \bar{P}_{t-1}) + \beta_{i0}(\bar{P}_t - \bar{P}_{t-1}) + (\alpha_i + \beta_{i0} + \beta_{i1} - 1)\bar{P}_{t-1} + \gamma_i X + \mu_{it}, \quad (15)$$

where

- P_{it} = price in local market at time period t , i runs from 1 to n markets;
- $\bar{P}_t$ = price in the central or reference market (Dhaka in the present study);
- X = other factors used as dummies for dry or monsoon seasons;
- α_i, β_i , and γ = parameters of the model to be estimated; and
- μ_{it} = the error term.

The model specifies the change in local price as a function of the change in the Dhaka market price for the same period, last period's spatial price margin, last period's Dhaka market price, and local market characteristics. In equation (15) β_{i0} measures the extent to which the local price at a given time is influenced by the change in the central market price during the same time period. It therefore reflects the extent and the rapidity of movement of information from central market functionaries to wholesalers, retailers, or farmers in the local markets so that they can act to adjust prices.

The term $(\alpha_i - 1)$ measures the extent to which last period's spatial price differential is reflected in this period's local market price change. If the margin widened in the last time period (because of a price rise in the central market) and transaction costs remained the same, traders would have an incentive to move rice away from the local market to another part of the marketing chain, thus pushing up prices in the current time period. Other forces might also influence local price changes. Periodic shortages in supply or disruption of communications by local storms or cyclones could influence local price changes and sever the links with the central market. Finally, the general level of prices in the central market may provoke price changes in the local market,

as is generally considered usual in an inflationary environment. This is reflected by β_{11} .

From equation (15) the following hypotheses can be tested:

Market Segmentation. The hypothesis that the local market is segmented from the central market means that the changes in the central market price will have no effect, immediate or lagged, on prices in local markets. In equation (15) market i is segmented if

$$\beta_{10} = \beta_{11} = 0. \quad (16)$$

This can be determined by testing equation (15) against the following restricted model with an F-test:

$$(P_{it} - P_{it-1}) = (\alpha_i - 1)(P_{it-1} - \bar{P}_{t-1}) + \gamma_i X + \mu_{it}. \quad (17)$$

If equations (15) and (17) are equal according to the F-test, then $\beta_{10} = \beta_{11} = 0$ and markets are segmented.

Short-Run Integration. This hypothesis requires that changes in the central market price be immediately (within the same month in the case of monthly data) and fully reflected in the local price. In terms of equation (15) it means that

$$\beta_{10} = 1, (\beta_{11} = 0), \text{ and} \quad (18)$$

$$\alpha_i = 0. \quad (19)$$

If both equations (18) and (19) are satisfied, market i is integrated with the central market in the same time period. Acceptance of the hypothesis makes $\beta_{10} = 1$ and $(\alpha_i - 1) = -1$, indicating that this period's central market price change and last period's spatial differential are fully reflected in the current local price level.

Absence of Local Characteristics. This hypothesis implies that $\gamma_i = 0$, and therefore it reduces to

$$\begin{aligned} (P_{it} - P_{it-1}) = & Y_0 + (\alpha_i - 1)(P_{it-1} - \bar{P}_{t-1}) + \beta_{10}(\bar{P}_t - P_{t-1}) \\ & + (\alpha_i + \beta_{10} + \beta_{11} - 1)\bar{P}_{t-1} + \mu_{it}. \end{aligned} \quad (20)$$

More generally, specifications of the X variables are limited to dummy variables defined over the same time frame as each price observation (for example, monthly price data require monthly dummy variables). Such a general specification enables the use of dummies for monsoon and winter-season months. Seasonality factors, if each market has different seasonal prices, could also be used in the form.

Equation (15) can be tested against equation (20) with an F-test in order to determine the significance of local characteristics. Equation (15) can also be manipulated to result in an indirect but more subtle and general indicator of market integration. Assuming that the central market is stable,⁷ and there is no effect of local characteristics on local prices, then (α_i) and $(\beta_{10} + \beta_{11})$ indicate the relative contributions of past local and central market prices to the determination of the current local price.⁸ If past central

⁷ Stability means $(\bar{P}_t - \bar{P}_{t-1}) = 0$. It may appear unrealistic, but if one considers that the condition is devoid of seasonal and inflationary effects, it may not be so.

⁸ For consistency, Ravallion's notation is used throughout.

market prices are the primary influences on local prices, the local market is well connected in that central market supply and demand factors are being transmitted to local markets and influence prices there.

Timmer constructed an index of market connection (IMC) in order to measure the relative influences of these two sets of forces. IMC is defined as the ratio of the lagged local market coefficient to the lagged central market coefficient.

$$IMC = \alpha_1 / (\beta_{10} + \beta_{11}). \quad (21)$$

If Ravallion's short-run integration is accepted, then $\alpha_1 = 0$ and $IMC = 0$ when markets are segmented, $\beta_{10} = -\beta_{11}$ and $IMC = \infty$. Given the model's specification, $(\alpha_1 - 1)$ would be between 0 and -1 under normal conditions and the index would normally be positive. In general, the closer the index is to 0 the greater the degree of market integration. Timmer, allowing for the assumptions of stability in central market prices and the absence of local characteristics, considered that a value of IMC less than 1 reflected a high degree of short-run market integration.

Data for the Investigation

Data for such a sophisticated analysis have to be modestly disaggregated and accurate. For this reason, instead of using average prices at district levels, market prices at 67 Bangladesh markets were obtained from the Department of Agricultural Marketing. These were weekly prices for coarse and medium-quality rice, collected from periodic markets and aggregated to monthly averages. Preliminary examination of this data set revealed that information for certain months was missing for certain markets. The distribution of missing data, which reflects the extent of inactive markets (Figure 14), indicates that most of the missing data pertain to the months of July, August, September, and October. These are the months when rural transport and the communication system are handicapped by monsoon and postmonsoon rains and floods, and markets are occasionally disrupted by these natural hazards. Rice markets are also generally thin in September and October. This is a tentative indication that rice markets lack complete market integration, at least in the short run.

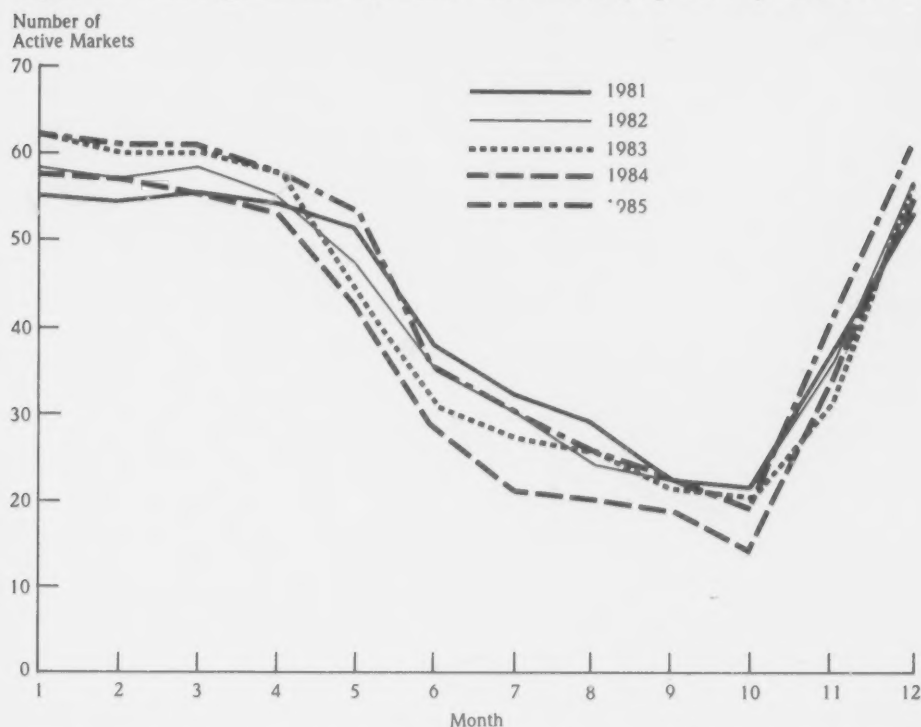
Because the analytical framework developed earlier requires that there be no missing data for any month for a market, only those markets that had price data for all months were selected. Only 19 out of 67 markets met this condition. This choice of markets may bias the results toward integration if only because the chosen markets were more active than those not selected.

Results

Segmentation of Markets. The error sum of squares (ESS) for restricted (equation 15) and unrestricted (equation 17) forms of the model and F-statistics for testing the hypothesis that markets are segmented are given in Table 15. The data cover the period 1981-85.

The hypothesis that a market is segmented—totally lacking in integration—where price changes in a local market depend only on past prices in that market is rejected at the 1 percent level of significance for every market. Most of the tested markets fall geographically within northern, western, and southern parts of Bangladesh; therefore, the conclusion is not valid for eastern and northeastern regions. Because eastern districts of Bangladesh are infrastructurally better connected with the central Dhaka market, market segmentation is less likely in these areas than in the areas covered by the tested markets (except in the Chittagong Hill Tract).

Figure 14—Average number of active rice markets, by month, 1981-85



Source: Weekly price data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

Short-Run Market Integration. A lack of total segmentation of markets does not imply that markets are well integrated or integrated at all times. The degree of integration may be weak, and this may be more so at certain times. The results for the hypothesis that the monthly prices on markets are integrated even in the short run are given in Table 16.

Timmer's IMC ratio for evaluating short-run integration was less than 1 in 3 cases out of 19, and the β_{10} coefficients were less than one standard error away from unity in 6 additional markets.⁹ Thus, at first glance, only three of the markets show any short-run integration or integration within the domain of monthly prices. Six others reflect Dhaka price changes without exhibiting signs of significant short-run integration. The rest are poorly integrated with the Dhaka market. However, as mentioned earlier, weekly data collected for 67 markets throughout Bangladesh showed a significant drop in the number of markets reporting prices during monsoon months. Thus, if a dummy for the rainy season is added to acknowledge that markets may be well connected

⁹ If β_{10} is close to one but the IMC is high, short-run integration is not likely; yet reference market price changes are being passed along. In this study, that result is viewed as a sign of some integration.

Table 15—Results of a test for segmentation of markets, using the error sum of squares, 1981-85

Market	District	Error Sum of Squares		F-Statistics
		Unrestricted	Restricted	
Joypurhat	Bogra	0.1562	0.3174	28.893
Gaibandha	Rangpur	0.1559	0.3791	40.082
Rangpur	Rangpur	0.0801	0.1748	33.081
Kurigram	Rangpur	0.1359	0.2909	31.923
Rajshahi	Rajshahi	0.1016	0.2201	32.664
Nowabganj	Rajshahi	0.1141	0.2526	34.022
Natore	Rajshahi	0.0680	0.1841	47.859
Naogaon	Rajshahi	0.1010	0.2195	38.142
Dinajpur	Dinajpur	0.1483	0.2957	27.847
Thakurgaon	Dinajpur	0.0909	0.2147	38.171
Sherajganj	Pabna	0.1124	0.2759	40.716
Kushtia	Kushtia	0.0568	0.1475	44.785
Chuadanga	Kushtia	0.0509	0.1358	46.736
Jessore	Jessore	0.0919	0.2476	47.438
Khulna	Khulna	0.1003	0.2258	35.049
Barisal	Barisal	0.1276	0.3081	39.187
Jhalkati	Barisal	0.1514	0.3612	38.815
Patuakhali	Patuakhali	0.2593	0.5255	28.757
Faridpur	Faridpur	0.0507	0.1540	57.076

Table 16—Results of a test for short-run integration of markets, using the index of market connection, 1981-85

Market	Index of Market Connection			β_{10} Coefficient
	Dry Season	Monsoon Season	Whole Year	
Joypurhat	1.52	2.71	2.72	0.98
Gaibandha	0.60	1.88	1.55	1.05
Rangpur	NS	1.83	2.84	0.82
Kurigram	2.01	NS	0.87	0.79
Rajshahi	1.06	1.28	1.36	0.81
Nowabganj	0.94	1.74	1.46	0.85
Natore	0.78	NS	1.79	0.83
Naogaon	NS	2.24	1.09	0.78
Dinajpur	0.48	0.76	1.03	0.81
Thakurgaon	NS	1.24	1.31	0.79
Sherajganj	1.11	2.30	2.42	0.97
Kushtia	1.75	NS	1.44	0.77
Chuadanga	0.50	1.50	0.87	0.73
Jessore	0.70	NS	0.50	0.84
Khulna	1.35	1.71	1.78	0.85
Barisal	1.40	1.35	2.10	0.98
Jhalkati	1.46	1.40	2.54	1.09
Patuakhali	1.08	2.27	1.89	1.11
Faridpur	0.80	NS	1.54	0.81

Notes: NS means the number is nonsignificant. β_{10} measures the extent to which the local price is influenced by a change in the central market price.

during part of the year but poorly linked in other months due to adverse weather, just under half of the markets (9 out of 19) are highly integrated with the central market during the dry season (three others have β_{10} near one). Even in the dry season about 36 percent of the markets are relatively weak in intermarket linkages. During the monsoon season (July-October) about 74 percent (14 out of 19) of the markets are poorly integrated (their IMC is greater than one), and 26 percent remain highly integrated with the central market even in the monsoon months.

Policy Implications

In the context of the present study, the analysis of market integration has the following implications:

First, the absence of segmentation of markets, as evidenced by the various tests, implies that price analysis at the aggregate level is valid. If it were not, the stabilization program and its associated model would have required as many versions as there were independent segments in the market.

Second, even though the markets are not segmented, the degree of integration (the extent and rapidity of transmittal in price signals from one market to another) is weak at some market locations and at some times of the year. This implies that the government cannot be sure that, by undertaking procurement or open market sales in only a few centers, it will automatically influence prices in all markets. In the aman season, particularly for procurement, a greater than normal effort may be required for successful procurement drives in Dinajpur, Patuakhali, Barisal, Bogra, and Rajshahi. In aus season, procurement efforts should focus on Chittagong division in particular and on the Jessore-Kushtia belt in general.

Third, although the present study is geared to short-run price stabilization issues, a long-run solution also lies in development of infrastructure in the northern and southern parts of Bangladesh, which would strengthen integration of markets and facilitate the efforts of the price stabilization scheme.

AN APPROACH TO PRICE STABILIZATION

The extent of the price fluctuation shown in Chapter 4 raises an important question. Why has Bangladesh not been as successful as Indonesia in reducing price fluctuation, despite roughly the same amount of public expenditure on intervention in the foodgrain market? After all, the two economies do not differ greatly in population, consumption patterns, and cropping patterns. Indonesia has been able to reduce both inter- and intrayear fluctuations in rice prices from 50-60 percent in the 1960s to 10-15 percent in the second half of the 1970s (Mears 1981). The difference can be traced to the orientation of the two programs. In Indonesia, stabilization of prices through targeting of ceiling and support prices within a price band is the principal policy objective. In Bangladesh, meeting quantity targets for various public distribution conduits is the principal explicit objective, while price stabilization is a secondary and implicit objective. In this chapter a framework for price stabilization, where policy objectives are enunciated as prices rather than quantities, is outlined. Quantities, however, are derived from prices in a consistent manner. After all, quantities are unavoidable for budgetary purposes. The framework is designed to be used by the government for planning the public-sector foodgrain program before the preparation of the annual budget. The Planning, Finance, and Food ministries should all find it helpful.

The framework consists of an analysis of the costs associated with a target price-band policy. The task requires the following steps:

1. Develop a short-term model for prediction in April-May of the annual average price most likely to prevail during the following July-June financial year;
2. Link the seasonal variations in prices, as analyzed in Chapter 4, to the predicted annual prices in order to arrive at predicted seasonal prices;
3. Estimate costs associated with various price bands in order to indicate the trade-off between the degree of price stability and the cost; and
4. Establish operating rules for managing annual and seasonal prices that should be consistent with the framework.

The details of these steps will be discussed further after a brief account of the current practices in management of the foodgrain system, which is necessary to clarify the differences between these practices and the proposed changes

Current Practices in Public Foodgrain Management

The public foodgrain system is based on a set of policies and an organizational structure designed to implement these policies. The Food Department, the primary organization, consists of a number of branches entrusted with the tasks of distribution, procurement, storage, transportation, inspection, and control. Publicly owned storage facilities have been developed to a capacity of 1.85 million tons in 1984, and these capacities are spread throughout the country. Major policy decisions are made at the highest level by the Ministers of Planning, Finance, Food, and Agriculture and the President. Initiative for changes in policies may come from any of these ministries, even though the formal processing of documents is conducted by the Food Ministry. A food policy monitoring cell assists the Secretary of Food in this process of policy formulation.

The normal exercise in short-run policy formulation begins in January or February and culminates before the preparation and finalization of the annual public budget on June 30. This budget pertains to the following financial year (for example, the budget presented on June 30, 1984, relates to July-June 1984/85). Extraordinary changes in policies may be made at any time. The budget exercise is comprehensive. It includes targets on revenue collection, foreign aid, current and capital expenditures, money supply and credit, the general inflation rate, exports, imports, production of trade-related goods, administered prices, and subsidies, and many others (see Bangladesh, Ministry of Finance 1985a and 1985b, and Bangladesh, Ministry of Planning 1985 for a sample of references).

In the context of the foodgrain system the budget exercise includes targets on how much grain is to be imported, how much is to be procured from domestic production, and how much is to be distributed through various public conduits. These targets are arrived at following procedures that do not explicitly incorporate a simultaneous and consistent price target for the market. This is what is meant by the characterization of the current policy as oriented to "quantity target rather than price target." The basis of arriving at these targets will be discussed further when quantitative relations concerning imports, procurement, and distribution are estimated. The formulation of these targets is influenced considerably by recent experience, political consideration, and most importantly, the prospect of domestic production. For example, how much foodgrain would be imported is normally estimated on the basis of a forecast of domestic production, the normal consumption requirement (generally 16 ounces per capita per day), and availability of food aid. In years not considered to be normal (politically unsettling years, election years) this rule may be violated to increase the import target. At the time of budget preparation, aus rice production is approximately known, but aman and boro rice and wheat production are only forecasts. Thus, considerable uncertainty surrounds the initial targets, but it may be possible to make corrections as information becomes more certain with the passage of time.

Government procurement from domestic production is voluntary on the part of sellers. Through its network of storage and purchasing centers, the government makes purchases at harvest time from farmers and small traders. Procurement target and procurement price are determined at the time of budget preparation. Past experience, production prospects, price trends, and stock in public godowns are some of the considerations that enter into the target determination. No formal procedure exists to check whether these targets are consistent with prospective prices.

Public distribution consists of rationing channels, open-market sales, relief grants, and food-for-work allocations. The rationing channel is divided into a number of outlets. Broadly speaking, urban consumers are subsidized through statutory rationing and rural consumers through modified rationing, though the latter channel is relatively small and irregular. Private, licensed dealers do the actual job of selling to ration card holders at regulated prices and predetermined quotas (see BECON 1986 for details). Open-market sales of foodgrains are still quite thin. These sales are the only component of the system that allows for direct action to bring down prices when the price level becomes too high. After this brief account of the current system, the main objective of developing a framework for price stabilization can be addressed.

A Model for Short-Term Price Determination

If planning for stabilization has to precede actions, it is vital that the government be able to predict price levels in the upcoming year, at least with a moderate degree

of reliability. The purpose of the model is, therefore, to predict an average annual price of rice that is valid for the upcoming budget year. Two considerations bear the utmost importance in developing this model. First, the model should be simple enough for staff economists and other professionals working at the country level to be able to work with it. In particular these professionals must be able to insert new values for variables as they become more certain and then reevaluate the price. Second, though simple in structure, the model should have reasonably strong predictive power. Prediction of prices is generally a frustrating task. The experiences of international organizations in predicting prices of commodities in international markets bear testimony to this frustration (Mellor and Ahmed 1987).

A Fully Specified Model

If determination of prices is to be based on underlying supply and demand parameters, then the framework should be a fully specified structural model that will provide predicted price along with consistent estimates of supply and demand parameters. Such a structural model for rice in Bangladesh is formulated as follows:

$$\text{Demand for rice: } MDR_t = f(Y_t, PR_t, SW_t), \quad (22)$$

$$\text{Supply of rice: } MSR_t = QR_t - QRP_t + RDP_t, \quad (23)$$

$$\text{Public procurement: } QRP_t = f(QR_t, PR_t, ADP_t, OS_t), \quad (24)$$

$$\text{Public distribution of foodgrains: } RDP_t = f(PR_t, ADPR_t, Z_t), \quad (25)$$

$$\text{Stock available to government: } Z_t = OS_t + MP_t, \quad (26)$$

$$\text{Opening stock: } OS_t = OS_{t-1} + QRP_{t-1} + MP_{t-1} - RDP_{t-1}, \quad (27)$$

$$\text{Import of grains: } MP_t = f(GAP_t, FA_t, WP_t), \text{ and } \quad (28)$$

$$\text{Demand-supply balance: } MDR_t = MSR_t, \quad (29)$$

where the expected signs of the partial derivatives are as follows:

$$\begin{array}{lll} \partial MDR_t / \partial Y_t > 0 & \partial MDR_t / \partial PR_t < 0 & \partial MDR_t / \partial RDP_t < 0 \\ \partial MDR_t / \partial SW_t < 0 & \partial QRP_t / \partial QR_t > 0 & \partial QRP_t / \partial PR_t < 0 \\ \partial QRP_t / \partial ADP_t > 0 & \partial RDP_t / \partial PR_t > 0 & \partial RDP_t / \partial ADPR_t < 0 \\ \partial RDP_t / \partial Z_t \geq 0 & \partial MP_t / \partial GAP_t > 0 & \partial MP_t / \partial FA > 0 \\ \partial MP_t / \partial WP_t < 0, & \partial QRP_t / \partial OS_t < 0 & \end{array}$$

where

MDR_t = market demand for rice in tons per capita,

Y_t = per capita real income in taka,

PR_t = price of rice in real terms (nominal price deflated by the index of manufactured goods' prices),

- SW_t = per capita production of wheat,
 MSR_t = market supply of rice in tons per capita,
 QR_t = per capita production of rice,
 QRP_t = public procurement from domestic production per capita,
 RDP_t = distribution of foodgrains per capita from the public rationing system,
 ADP_t = administrative procurement price in real terms,
 OS_t = opening stock of foodgrains per capita in government godowns,
 $ADPR_t$ = administrative ration price in real terms,
 Z_t = availability in government stocks,
 MP_t = import of foodgrains per capita,
 GAP_t = per capita gap between domestic availability of foodgrains and estimated requirements based on 16 ounces per capita per day,
 FA_t = food aid per capita,
 WP_t = world price of foodgrains (weighted average price), and
 t = year ($t = 0, 1, 2, \dots, n$).

The supply equation (23) has been formulated without a price variable in the argument because, at the time of the prediction exercise, production estimates of two out of three rice crops—aus and boro—are already known and the first forecast of the third (aman) is available but speculative.¹⁰

The eight equations above can be reduced to six by substitution of equations (22) and (23) in equation (29). These six equations can provide solutions for six of the endogenous variables: PR_t , RDP_t , QRP_t , Z_t , MP_t , and OS_t .

The equations are estimated by the three-stage least square method for estimation of a simultaneous system using the analysis with the limited dependent variables (LIMDEP) computer software program. The estimated equations are presented in Appendix 2, Table 25. The difference between the predicted and actual prices from this model is quite large in most years. The direction of relationship as indicated in the estimated equation is correct in almost all cases but the reliability of the coefficients is often quite low. For example, the estimated coefficient of the income variable (equation 22) shows the expected sign, but the *t*-statistic of the estimate is beyond the acceptable level of significance. The coefficient of wheat output (SW) can be interpreted as the additional units of rice demanded in substitution for a unit change in wheat

¹⁰ For the purpose of estimation of this and the other model in this study, boro rice in 1983/84 is found to be relevant for the 1984/85 market supply.

supply. This coefficient is expected to be negative but less than one in the context of the taste pattern in Bangladesh. The sign of the coefficient is correct but its absolute value is 4.2, substantially greater than one. Because the wheat price series was incomplete for the entire period, price could not be used for the supply of wheat in equation (22). Wheat is a relatively new product, which has gained substantial importance in the domestic production of grains only in recent years. Among the various equations in the system, the estimates of import equation (28) were found to be quite reliable, except for the coefficient of world price (WP).

Why this poor result with such a complete system? The following reasons may underlie the frustrating results. First, the 1960-84 (excluding 1972-75) data series had to be used to give enough degrees of freedom for reliable estimates. But the data pertaining to the 1960s are not reliable, particularly for certain variables. During this period Bangladesh (formerly East Pakistan) was a part of Pakistan and some statistics, such as per capita income and imports in certain years, were not originally available as direct measures. They were derived by various researchers for various purposes and therefore estimates vary considerably. Second, the economy of Bangladesh underwent significant structural changes after 1971, particularly for factors that affect prices. Thus, procurement from domestic production was mostly compulsory in the 1960s, while it was voluntary after 1970. The public distribution system has changed, with more administrative prices used to control offtake now than in the past. The political power structure accords higher priority to special groups and food-for-work outlets than was the case in the 1960s. Moreover, farmers now market about 30-35 percent of rice production compared with only about 10 percent in the early 1960s.

An Alternative Model

The foregoing discussions indicate that the prediction of price has to be based on a shorter data series, 1976-84, for example. Moreover, the emphasis is on prediction rather than estimation of parameters of supply and demand, even though these parameters are implicit in the price prediction model. The following price equation was the central basis for the prediction of price:

$$PR_t = f(Y_t, MSR_t, SW_t). \quad (30)$$

Price is shown in equation (30) as dependent on income, market supply of rice, and wheat production. Market supply consists of domestic production minus public procurement plus distribution from public stock. As explained earlier, domestic production, during the short period in question, is not a function of price. But public procurement and distribution are influenced by price as shown in equations (24) and (25) of the fully specified model.

Therefore, the system of equations adopted in this model consists of equations (30), (24), (25), and (23), where the expected signs of partial derivatives are $\partial PR_t / \partial Y_t > 0$, $\partial PR_t / \partial MSR_t < 0$, and $\partial PR_t / \partial SW_t < 0$. Other partial derivatives are expected to behave as indicated before.

In this system there are four endogenous variables and four equations; therefore, it is possible to find solutions for the four unknowns (PR_t , QRP_t , RDP_t , and MSR_t). Inspection of each equation further shows that the number of endogenous variables appearing on the right-hand side is less than the number of exogenous variables excluded from the relation; therefore, the parameters can be identified. The econometric estimation of the system was made by using the three-stage least square method and the LIMDEP computer software with the 1976-84 data set.

This abridged model differs from the complete one in the price equation used in place of independent supply and demand equations, the treatment of Z_t and OS_t as exogenous rather than endogenous, and the omission of the import (MPt) equation. Z , OS , and MP are interrelated. The equations for both Z and OS are identities. Therefore, treatment of MP as exogenous is implicit. Is it reasonable to assume MP as exogenous? In the very context of forecasting short-run prices when domestic production shortfalls are largely known, the treatment of MP as exogenous is not unrealistic. It is shown in Appendix 2, Table 25 that import decisions are mostly explained by the size of the gap in domestic production and the availability of foreign aid. These two variables are exogenous. Therefore, the implicit treatment of MP and the explicit use of Z and OS as exogenous are not as objectionable as it may appear. Moreover, single-equation ordinary least squares as well as simultaneous equation estimates show that OS has no influence on procurement and Z has only modest influence on public distribution. These variables are not significant.

The estimated equations of this system [equations (30), (24), and (25)] are presented in Table 17. Equation (23) is an identity. Data for the analysis are shown in Appendix 2, Table 26.

The Price Equation

The estimate of the price equation (30) is reasonable. The derived price and income elasticities of demand are -0.52 and 0.46 . These are consistent with estimates made earlier by other researchers (Mahmud 1981, Ahmed 1979). The income variable is lagged by one year to accommodate the flow of the income measured from the production account of national product to expenditure streams with a time lag. The variables MSR and SW are measured in tons per 1,000 persons, Y in taka per person, and PR in taka per maund. The nominal rice price is deflated by the manufactured consumer goods prices, and GNP is deflated by the general price index. The effect of wheat supply (domestic wheat production) on rice price is statistically not significant even though the direction of effect and the size of the coefficient are consistent with intuitive judgments. An increase in production of wheat is expected to depress the rice price

Table 17—Estimated equations of the rice price system

Equations and Variables	Coefficient Estimate	t-Value	Elasticity at Mean Values
Equation (30): price			
Constant	412.95	2.04	...
Y_{t-1}	0.08	4.80	0.88
MSR_t	-2.28	-1.97	-1.94
SW_t	-1.13	-0.36	-0.05
Equation (24): procurement			
Constant	39.92	1.49	...
QR_t	-0.25	-0.32	...
PR_t	-0.28	-2.61	-14.65
ADP_t	0.33	2.37	10.55
OS_t	-0.04	-0.17	...
Equation (25): ration distribution			
Constant	18.98	12.05	...
PR_t	0.06	1.90	0.76
$ADPR_t$	-0.15	-3.94	-1.21
Z_t	0.12	1.13	0.21

due to the substitution effect. Wheat production is only about 8 percent of rice production in recent years. Therefore, its effect on rice price through substitution in consumption is bound to be weak.

The Procurement Equation

Earlier efforts to estimate the procurement equation (24) in a single equation model were not satisfactory, but the estimated equation in a simultaneous system proves to be quite rewarding. The effect of rice production, QR , on procurement is not significant. The market price of rice and the administered procurement price exert significant influence on procurement of rice. The direction of the relation is correct, and the elasticities of procurement for these two prices are quite high but not equal, which indicates that the effects on procurement of market price and administered price are not symmetrical. It must be remembered, however, that procurement is a seasonal activity and estimation of the equation within a framework of annual statistics may not provide a complete picture, even though the effect of prices on procurement is clearly established. Various nonprice factors (the extent of purchasing centers, financial resources at the disposal of the procurement agency, and so forth) could play important roles. These factors should not be ignored when procurement decisions are formulated in the context of the price stabilization program enunciated here.

The Ration Equation

The estimated equation for per capita ration offtake (equation 25) also gives good results. It is apparent that both the market and administered ration prices in real terms have correct signs; however, administered price has a much stronger effect on the level of offtake. These results confirm recent findings that relative prices have become more influential in determining foodgrain offtake from the public system in recent years (Montgomery 1985). Availability of government stock (Z) is only a weakly significant factor in determining the level of public distribution.

Predictive Power of the Model

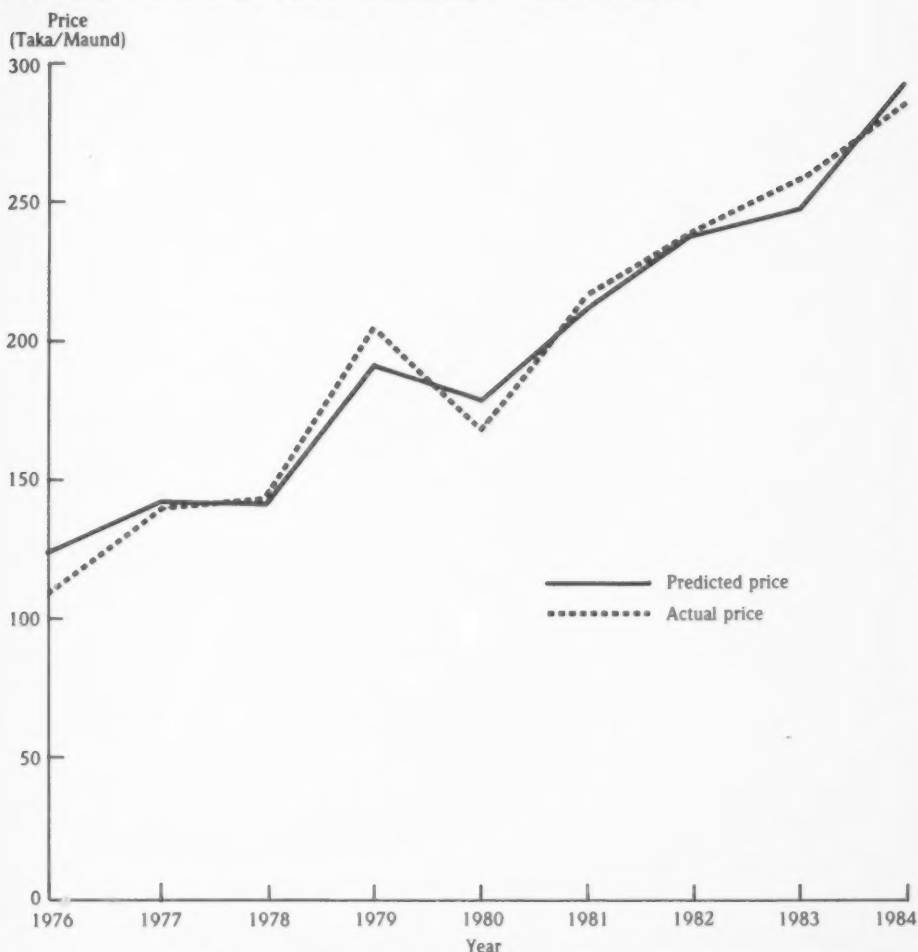
How reliable is the model in predicting rice prices in Bangladesh? One way to determine this is to see how well the predicted values fit actual past prices (see Figure 15). The predicted prices for various years are obtained by inserting the values of exogenous variables in each year in the estimated equations of the alternate model (equations 30, 23, 24, and 25) and then solving for the endogenous variables in a simultaneous manner, using a computer program. The predicted prices thus obtained are converted to nominal terms by multiplying the real prices with the deflators.

It is reassuring that the model is remarkably consistent with historical experience. However, whether it will continue to be so in the future depends partly on the capacity of users to update the model as time passes by. Moreover, users will have to keep this monitoring mechanism up-to-date to take into consideration effects of nonprice factors (such as election-year actions, booms in construction activity, and floods). Only local analysts can assess these factors and modify predictions accordingly.

Application of the Model to Price Stabilization

Using the framework developed above to stabilize prices involves several steps. In the first step, prices are predicted from the production forecast in order to select a target annual average price. According to the concept, a price band that reflects norma-

Figure 15—Predicted versus actual price of rice, 1976-84



Source: Actual prices are from data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

tive as well as efficiency considerations provides the domain from which a particular price target is selected. In the second step the annual average price is linked with the seasonal pattern of prices, which provides a guideline for the seasonal activities of procurement and distribution of foodgrains that should be consistent with the average price target. The third step stipulates the operational rules for organizing domestic procurement and distribution as basic instruments for stabilization.

Price Band

Within what band of prices should a country stabilize its annual real prices of foodgrains? A narrower band costs more, whereas a wider band provides a smaller degree of stabilization but costs less. One reason costs rise as prices become more

stable is because private traders react to price stabilization policies of governments. When the band is so narrow that it does not allow private traders to make a normal profit from stocking foodgrains, the government has to undertake an increasing amount of stocking and market operation to bring about the desired degree of price stability, and this implies an increasing rate of cost. On the benefit side, a higher degree of price instability not only affects producers and consumers in the ways described in Chapter 3, but it strains the limits of political tolerance to instability in foodgrain prices. It is assumed, in the context of Bangladesh, that political tolerance is the deciding criterion for selecting the degree of price stability and the price band. This assumption derives its validity from the behavior of the government in management of food policies during the past decade.

Even though political considerations play a dominant role, cost considerations are also important. The incremental quantity of foodgrains that the public system should be prepared to sell on the open market and the costs of price stabilization are shown later. Here the procedure for arriving at a price band is specified.

For operational purposes, nominal prices are relevant. The conversion of real to nominal prices and the derivation of a price band in nominal annual prices is accomplished through the following formulation. Suppose that NP_0 is the nominal normal price in the base year, NP is the nominal price in the price band in the following year, v is the annual price band in real terms (a 4 percent band, for example, implies 4 percent up and 4 percent down), and i is the rate of inflation. Then the upper bound is $NP_U = NP_0[1 + (i + v)]$ and the lower bound is $NP_L = NP_0[1 + (i - v)]$. For example, when the base-year nominal price is Tk 300 per maund, the expected inflation rate is 10 percent, and an annual price band of 4 percent is chosen, then the upper-bound nominal price is Tk 342 and the lower-bound nominal price is Tk 318. It is clear that the lower-bound nominal price can be below the price in the base year when the inflation rate is smaller than the price band as defined here. Historical price data in Bangladesh show that nominal prices in some years have fallen below the prices of previous years even when inflation rates were positive.

Linking Annual and Seasonal Prices

The crop harvest seasons and seasonality of prices that have prevailed in recent years were explained in Chapters 2 and 4. For the purpose of price stabilization three trough and peak price seasons are relevant. These are the second-lowest price season (S_1), generally prevailing in the months of July-August-September; the lowest price season (S_2), prevailing in December-January; and the peak price season (S_3), prevailing during April-May-June. Prices in other months fall in intermediate zones having little relevance for price stabilization. The relationships between these seasonal prices and the annual price can be written as follows:

$$PS_1 = PA(SF_1), \quad (31)$$

$$PS_2 = PA(SF_2), \text{ and} \quad (32)$$

$$PS_3 = PA(SF_3), \quad (33)$$

where PS is the seasonal average price of rice in a particular season, PA is the annual average price of rice in a particular year, and SF is the seasonal factor (see Chapter 4). The actual price in any season of a year would be different from the estimated price on the basis of this formulation, because of these irregular factors unrelated to domestic

production. Prices in the same season of different years are explained by the difference in annual prices as well as these irregular factors. Thus, annual prices capture trend or inflationary effects when year-to-year comparisons in nominal seasonal prices are attempted.

It is obvious that the average annual price picks up the inflationary factor all at once, even though a certain rate of inflation in a given year may be distributed over the seasons or months within that year in an increasing or a decreasing order. This fine-tuning of the link between annual and seasonal prices can be undertaken if distribution of inflationary forces within a year can be obtained. The analysis of the trend-cycle factor, presented earlier, indicates that in different years there are different patterns of distribution of the monthly trend-cycle factors. In years of normal inflationary force this fine-tuning may not be necessary, but in abnormal years such sequencing of inflationary factors is unavoidable.

Using the example in the previous section where the upper-bound annual average price was estimated at Tk 342 and the lower-bound price at Tk 318, the seasonal prices related to that price band can be determined. Suppose the annual target price within the Tk 342-318 range in a particularly bad crop year is Tk 342. Then the peak season or ceiling price with a seasonal factor of 8 percent (typical of Bangladesh) is Tk 369 and the S_2 , the slack or harvest season price (or support level for price), is Tk 315. In a good crop year when the target price is the lower-bound annual average price of Tk 318 per maund, the relevant ceiling or peak season price for this year would be Tk 343 and the support or harvest season price would be Tk 293 per maund.

Simulation of the Stabilization Model

The simulation exercise reflects the price stability and application of policy instruments that would have prevailed during 1976-84 had the stabilization model formulated here been in operation then. This exercise is based on the assumption that a 4 percent price band in annual prices and an 8 percent price band in seasonal prices are the ranges within which the government allows prices to vary with changes in domestic production. In light of the earlier discussion, these price ranges are consistent with private trade making a normal profit.

The simulated and actual price regimes for rice shown in Table 18 are developed according to the following procedures.

1. The predicted prices (column 1, Table 18) are derived from the solution of the alternate model described earlier. The real prices are converted into nominal terms using the price deflator.

2. Then the normal prices—the trend prices for each year—are estimated from the trend equation based on 1968-84 time series (excluding 1973/74 and 1974/75). If for any year the predicted price is higher or lower than the normal price, then the upper- or lower-bound price is selected as the target annual price (column 2). For example, in 1976/77 the normal price, Tk 112.3, is lower than the predicted price, Tk 124.3. Therefore, the target price is derived by multiplying the normal price by the factor 1.04. The year 1978/79 demonstrates the case when the lower-bound price becomes effective. In this year, the trend or normal price was Tk 154.3, which was higher than the predicted price of Tk 142.6. Therefore, the target annual price for 1978/79 is Tk 148.1 ($154.3 \times 0.96 = 148.1$). See Appendix 3 for notes on modifying the procedure in future years and for adjusting the long-run price alignment.

3. The target floor price is obtained by multiplying the target annual price by the seasonal factor of 0.92 (1.00-0.08). Similarly, the target ceiling price is derived by multiplying the target annual price by the seasonal factor of 1.08.

Table 18—Actual prices of rice, 1976/77-1984/85, compared with prices simulated by the model

Year	Predicted Annual Price	Target Annual Price ^a	Target Ceiling Price	Target Floor Price	Actual Annual Price	Actual Ceiling Price	Actual Floor Price	Difference Between Actual and Target Prices		
								Ceiling ^b	Floor ^c	Annual ^d
				(taka/maund) ^e					(percent)	
1976/77	124.3	116.8	126.1	107.5	110.0	129.9	98.1	3.0	8.7	6.2
1977/78	142.2	138.6	149.7	127.5	139.0	150.0	125.0	0.2	1.9	-0.3
1978/79	142.6	148.1	159.9	136.3	144.9	183.0	129.0	14.4	5.3	2.2
1979/80	191.5	182.3	196.9	167.7	204.7	233.0	182.0	18.3	-8.5	-10.9
1980/81	178.1	188.5	203.6	173.4	168.9	180.8	155.9	-11.2	10.1	11.6
1981/82	211.6	208.6	225.3	191.9	216.3	291.0	181.0	29.1	5.6	-3.7
1982/83	237.2	228.8	247.1	210.5	239.6	265.0	218.0	7.2	-3.6	-4.5
1983/84	247.7	248.9	268.8	229.0	257.2	282.0	233.0	4.9	-1.7	-3.2
1984/85	292.9	291.5	314.8	268.2	286.0	316.5	246.9	0.5	7.9	1.9

Source: Computed from actual price data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

^a The text explains how this target is arrived at.

^b The difference between target and actual ceiling prices is expressed as a percentage of the target ceiling price.

^c The difference between the target and actual floor prices is expressed as a percentage of the target floor price.

^d The difference between the actual and target annual prices is expressed as a percentage of the actual price.

The nature of the price fluctuation between the proposed and the existing modes of stabilization is examined in Table 19. If the proposed mode of stabilization had been operative during 1976-84, the fluctuation in annual prices would have varied from 3.4 to 23.1 percent, as compared with variations of -17.3 to 41.3 percent under the existing system. The proposed stabilization model allows some variation in annual prices but it contains severe fluctuations. Seasonal (or intrayear) fluctuations are also reduced under the proposed mode of stabilization. Seasonal prices vary by a stable 15 percent every year in the proposed model compared with variations from a low of 13.8 percent in 1980/81 to a high of 37.8 percent in the following year under the existing system.

What are the implications for policy instruments associated with the two modes of stabilization? The comparison of actual public procurement and distribution figures and those that would have been required under the proposed procedure are shown in Table 20. The simulated procurement and distribution figures in the table were derived by examining monthly prices. If the actual ceiling price in a particular month is above the ceiling price, then the quantity required to bring down the actual to the target ceiling price is estimated using equation (30). All monthly requirements are added to arrive at the incremental quantity of open market sales that the government should have undertaken. These quantities are shown in column 3 of Table 20.

The incremental quantity that the government would have to procure over the amount acquired with the existing procedure to support the floor price is estimated following a similar month-by-month evaluation of prices. If the actual floor price is lower than the target floor price, then the additional quantity to be procured to bring up the actual to the target floor price is estimated using equation (30). All such monthly estimates are added to arrive at the total additional quantity of procurement. It must be noted that distribution and procurement are seasonal operations, but their estimates are based on equation (30), which is based on annual data. A complete model based on seasonal prices is not possible due to the data problems described in Chapter 5. It

Table 19—Actual variability in rice prices compared with variability under the proposed model, 1976/77-1984/85

Year	Proposed Model		Actual Figures	
	Fluctuation in Annual Price ^a	Fluctuation in Seasonal Price ^b	Fluctuation in Annual Price	Fluctuation in Seasonal Price
	(percent)			
1976/77	...	14.8	...	24.5
1977/78	18.7	14.8	26.4	16.7
1978/79	6.9	14.8	4.2	29.5
1979/80	23.1	14.8	41.3	21.9
1980/81	3.4	14.8	-17.5	13.8
1981/82	10.7	14.8	28.1	37.8
1982/83	9.7	14.8	10.8	17.7
1983/84	8.8	14.8	7.3	17.3
1984/85	17.1	14.8	11.2	22.0

Source: Actual fluctuation figures are computed from data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

^a The fluctuation in annual prices is the difference in prices between years t_n and t_{n+1} measured as a percentage of the price in t_n .

^b The fluctuation in seasonal prices is the difference in the ceiling (Cn) and the floor (fn) prices measured as a percentage of Cn.

is hoped that this difference in method does not make a substantial difference in outcome. What it implies, however, is that actual operation of procurement and distribution activities has to be closely monitored, and these activities should be changed according to the actual response in ceiling and floor prices.

The tasks of procurement and distribution under the proposed procedure vis-à-vis the actual procedure can be examined, keeping the background explanation in mind. For both public open market sales and procurement, 1977/78 appears to be a year when the current procedure and the proposed model are almost the same. In 1976/77, as well as 1978/79 and 1980/81, procurement should have been larger than it was. There should have been no procurement in 1979/80 and procurement quantities

Table 20—Actual public distribution and procurement of foodgrains, 1976/77-1984/85, compared with quantities simulated by the model

Year	Public Distribution			Procurement from Domestic Production		
	Actual	Simulated	Difference	Actual	Simulated	Difference
	(1,000 metric tons)					
1976/77	1,216	1,266	50	313	680	367
1977/78	1,557	1,569	12	541	557	16
1978/79	1,483	1,570	87	317	580	263
1979/80	1,784	2,479	695	226	0	-226
1980/81	1,123	808	-315	841	1,390	549
1981/82	1,344	1,662	318	287	241	-46
1982/83	1,190	1,440	250	168	141	-27
1983/84	1,205	1,475	270	145	128	-17
1984/85	1,327	1,340	13	133	286	153

Source: Actual figures are from Bangladesh, Bureau of Statistics, *Statistical Yearbook, 1985* (Dhaka: BBS, 1986).

should have been smaller than they actually were in 1981/82 through 1984/85. This could have been accomplished by adjusting the procurement price as reflected in equation (24).

For public distribution, the sharpest departure of simulated from actual occurs in 1979/80. This was a semifamine year in Bangladesh when actual open market sales of an additional 695,000 tons could have prevented the price from going above the ceiling. On the other hand, public distribution of foodgrains in the following year, 1980/81, when crops were good, should have been about 800,000 tons instead of the actual distribution of 1.12 million tons. This could have been accomplished by adjusting the administered price downward in 1979/80 and upward in 1980/81 (equation 25).

Cost Implications

The higher the degree of price stabilization, the higher should be the cost to the public exchequer. It is this budgetary cost that is estimated here.

As discussed in Chapter 3, budgetary costs include the administrative costs, costs of the discretionary food subsidy meant for welfare of the poor, and the costs involved in maintaining foodgrain stocks. The cost estimates below relate to the cost of stock only for a number of reasons. First, stocking cost is by far the largest of the three components. Second, the administrative and discretionary subsidy costs can be treated as fixed costs. Only the stocking cost is implicated by the adoption of the new procedure for price stabilization; it does not impinge on the other two aspects of costs that are related to the existing program. Moreover, it is not feasible to disentangle the various elements of costs under the present program from those related to price stabilization and those directed to food subsidy objectives. Therefore, comparison of the costs involved in the proposed model with those of the existing model is made on the basis of current stocking costs vis-à-vis the stocking costs under the proposed system.

Thus the question becomes one of determining how much stock is maintained for the current system and how much will be required for the proposed system. It does not consider complications surrounding the issue of an "optimal stock," which is itself an important but controversial issue in Bangladesh. The stock maintained for running the current system is available year by year. The mean stock level of 1976/77-1984/85 is taken as the stock for the current system. Additional stock required for the proposed system is determined on the basis of how much is needed for the additional public sales and purchases necessary for implementing the proposed system. This estimate is roughly equivalent to the mean incremental public distribution (based on column 3 in Table 20) plus two standard deviations of the distribution. No additional stock is necessary for procurement operation. The estimated stock for public distribution will meet the needs for the first four to six months of a year and thereafter will be replenished from domestic procurement or imports or a combination of both. Thus, the estimate of incremental stock for the proposed model takes into account the opportunity for trade.

The estimated stocks and their costs shown in Table 21 indicate that public stock of foodgrains would have to increase by about 700,000 tons if the proposed system of price stabilization were adopted without reducing the current magnitude of the rationing program. In reality, the environment of stable market prices that the proposed system would bring about might reduce the pressure on ration distribution. In that event, the actual incremental cost for the proposed program would be smaller than the estimate shown in the table. Introduction of the proposed system implies a gradual transition from a system geared more to ration distribution to one oriented more to open market sales by government.

Table 21—Comparison of costs related to the current (1986/87) and the proposed systems of price stabilization

Price Bands ^a	Stock Required for the Cur- rent System	Incremental Stock Required for the Pro- posed System	Cost of Current System ^b	Incremental Cost for the Proposed System
	(1,000 metric tons)		(Tk million)	
4 percent band in annual prices and 8 percent band in seasonal prices ^c	668	700	541.1 (\$16.4)	567.0 (\$17.2)
4 percent band in annual prices and 10 percent band in seasonal prices	668	470	/ ...	380.7 (\$11.5)

^a The price band system is not applicable to the current system.

^b Cost estimates are based on Tk 5,400 per ton of rice and an interest rate of 15 percent per year. The figures in parentheses are U.S. dollar equivalents at the official exchange rate in 1986/87.

^c This price band and its related procurement and distribution figures are shown in Table 20.

The cost of the proposed system could be reduced further if the political tolerance to price instability could accept a wider price variation.

Operating Rules and Use of Policy Instruments

Price Targets and Stock

Planning for the next year's stabilization program should begin with the determination of a price target within the price band at the end of the current year. Although price-based planning of the food system would be a shift from the current practice of quantity planning, it would not mean that quantity targets would be abandoned, considering that budgetary planning cannot proceed without quantitative physical targets. Quantity targets are derived with some degree of consistency from the price targets.

Before deriving price targets, one should be sure that the price band is set correctly. In the initial phase of the shift from the existing to the proposed system, it is advisable to be cautious and to permit a price band to evolve over time that is optimal in the sense that it leaves no scope for sub- or supernormal profits in trading. A 4 percent band in annual prices and an 8 percent band in seasonal prices is appropriate to begin with because it is consistent with current frequencies of heightened interventions through open market sales and fluctuations in real prices. Such a price band is normal for traders in interyear stocking of foodgrains.¹¹

The selection of a target price and estimation of the predicted prices are clearly dependent on production and income estimates. As indicated earlier, estimates of effective production for aus and boro for the next year (say 1985/86) are available with certainty at the time of the annual planning exercise in 1984/85. Cereals forecasts of aman rice and wheat are available then. Even though some adjustment in target and predicted prices is possible as later forecasts come in, public stock plays a more crucial

¹¹ No recent empirical study is available to support this point, but a past study by Farouk (1970) and discussions with current traders lend credence to it.

role in adjustment than target or predicted prices because, even if better estimates are available in the later part of the year, it is too late for imports to be shipped and received in the same year. Thus, correctly estimating the variability of aman and wheat production is critical for determining the size of stock required for price stabilization.

Analysis of data for 1975-85 indicates that the maximum fall in production of aman and boro in any year was about 865,000 tons. A shortfall of 500,000-600,000 tons in aman production can be expected in 2 out of every 10 years. A 600,000-ton shortfall in rice is equivalent to a shortfall of 960,000 tons of foodgrains with 60 percent wheat and 40 percent rice for the purpose of stabilizing rice prices in Bangladesh.¹² Therefore, an opening stock of about 1 million tons of foodgrains appears to be a critical requirement for stabilization of prices.

Historically, the opening stock in public godowns averaged about 650,000 tons, but in certain years the opening stock was as low as 200,000 tons, which is considered to be of no effect when operational problems are taken into consideration. The physical capacity of public godowns to hold stock runs as high as 2 million tons. A stock of up to about 1 million tons is not likely to be constrained by administrative ability to manage it.

For price stabilization, it is better to err on the side of maintaining a too-large stock than to hold too small a stock, because the price forecast is difficult to make, and private stockholding may be greatly influenced by the level and stability of public stock. Although no treatment of private stock is included in this analysis, it nevertheless influences market price, mainly because information on private stock is seldom available. Empirical evidence on the relation between private and public stock is rare. A study in Indonesia has shown that private traders' speculative behavior is extensively molded by the ability of government to act in markets (Siamwalla 1987). This ability is generally reflected in the level of public stocks. A recent survey indicates a similar behavioral response among rice traders in Bangladesh. This survey, which attempts to make a qualitative assessment of factors relating to stocking decisions of traders, shows that none of the ration variables such as ration price, quota, or offtake enter into stocking decisions of rice traders. On the other hand, more than 90 percent of traders in both wholesale and retail groups consider open-market sales of foodgrains by the government an important factor in their stocking decisions (BECON 1986, Shahabuddin 1987). Of course, the ability of the government to conduct effective open market sales, particularly during the October-November peak price season, depends greatly on opening stock.

Imports and Public Distribution

Imports and public distribution are intimately connected in the food policies of Bangladesh. The determinants of imports have been examined previously (see Appendix 2, Table 25 for results of regressions with import data). This analysis shows that shortfalls in domestic production and availability of food aid are the principal determinants of imports. There are various other political and vested interests often considered as factors of inducements to import, but no basis exists to describe, much less to quantify, these speculative efforts.

Shortfalls in domestic production are central to determining the required volume of imports. As shown in Chapter 5, assessments of production loss due to natural

¹² It has been found, on the basis of price relations between rice and wheat, that the influence on market price of rice from the increase of market supply of one unit of rice, all else being equal, is equivalent to the same influence from the increase in wheat supply by 1.6 units (Ahmed 1979). This factor is used to convert rice into wheat equivalents.

calamities tend to be overstated during floods and understated during drought. Also, private stock, an unknown quantity, may have a tendency to decline sharply following sequential repetitions of natural calamities. Therefore, natural calamity, if it occurs repeatedly, may affect supply and prices more seriously than would be indicated by the sum of crop damages from sequential natural calamities. These considerations warrant a careful monitoring of crop production and forecasts.

Income has a more important effect on demand for foodgrains and hence on their prices in Bangladesh than in developed or many other developing countries. Estimates of income should be based on the gross national product (GNP) rather than on the gross domestic product (GDP). In this analysis the relationship with GDP as the measure of income was inconsistent. GNP per capita has increased faster than GDP per capita since 1977/78, implying an increase in the contribution of the external accounts to the economy of Bangladesh. The effects of income as well as price levels, given the target price for stabilization, should be taken into consideration in estimating the import target. The current practice of estimating the consumption requirement at the rate of 16 ounces of rice per capita per day should be revised to include income and price effects.

Internal Procurement

The first estimate of the target of procurement is derived from the difference in the price target and the predicted prices elaborated in Tables 18 and 20. This estimate, based on the annual aggregate, is only a rough approximation, however, because procurement is largely a seasonal activity influenced by various seasonal and regional diversities. It will require fine-tuning based on up-to-date knowledge of regional diversities, if possible.

The need for flexibility in the procurement program arises from another reason alluded to earlier. Seasonal prices are often influenced by erratic behavior of factors that are hard to identify. The stock decisions of private traders, including large farmers, are dominant among them. Generally, when a good crop follows a bad crop, the harvest season fall in price is not as sharp as when a good crop follows two successive bad crop seasons. Similarly, election year expenditures or other sudden spurts in public expenditures may induce unpredictable pressure on the demand side, which may cause harvest and peak season prices to deviate from normal patterns. Some degree of flexibility in both procurement and open market sales programs is necessary to counter these erratic influences.

CONCLUSIONS

More than 100 million people live in Bangladesh, and the country is known worldwide for its extreme poverty. With no room for extension of cultivated land, the increasing pressure of population has resulted in fragmentation of farms into smaller and smaller units and created a tremendous need for expansion of nonagricultural employment. The number of households depending on markets for supply of foodgrains has been increasing rapidly. Rice is the dominant foodgrain in the diet of the population; thus stability of rice prices is critical to social stability in Bangladesh. Because of the influence of rice prices on prices of jute and other cash crops, stability in the rice market implies a stable environment that is necessary not only for growth of agriculture but growth of the entire economy. A modest success in adoption of modern technology in agriculture has been found to coincide with a greater degree of variability in rice prices in recent years.

No government in Bangladesh can afford to keep aloof from the happenings in the foodgrain sector. But intervention in foodgrain markets involves costs in resources that are required for long-term programs to eradicate poverty. Therefore, government intervention is required for efficiency, and it is limited to the containment of extreme fluctuation of prices and supply. In the past, the government primarily depended on the rationing system to keep prices from rising abnormally. In recent years, the government has used ration distribution, open market sales, and postharvest procurement for stabilizing prices. Application of these policy instruments is based on targets of quantities to be distributed, imported, and procured from domestic production. In the absence of a consistent approach based on price instead of quantity targets, the government's efforts have been relatively ineffective and wasteful.

The framework for stabilization of rice prices in Bangladesh accommodates operations of private traders as principal actors in consonance with a complementary public intervention in foodgrain markets. The framework and operational principles stipulated here may seem cumbersome to those who are generally reluctant to make a change in the management of Bangladesh's food sector. But the procedure is in fact relatively simple. As mentioned earlier, the current system is relatively ineffective in maintaining stability in market prices, and the urgency of continuing the rationing system is also likely to diminish once a stable price environment is established. The existing Food Monitoring Unit (FMU) under the Ministry of Food can provide the institutional basis for application of the framework. A small amount of investment to upgrade the skill and professional strength of FMU will enable it not only to adopt the framework as developed here but also to improve upon it as new experience is gained through its application.

APPENDIX 1:

THE CENSUS X-11 PROCEDURE

The Census X-11 procedure is a Fortran-based program for decomposition of time-series data into component parts. The basic steps for computing each iteration of estimates of the seasonal (S), irregular (I), and trend (T) factors are listed below. The procedure executes three iterations to stabilize the irregular and seasonal components.

1. NP = nominal price series,
2. T1 = 2×12 -term moving average of NP (first trend estimate),
3. SI1 = NP/T1 (first seasonal, irregular estimate),
4. S1 = 3×5 -term moving average of SI1 (first seasonal estimate),
5. End points are filled in,
6. I1 = SI1/S1 (first irregular estimate),
7. SI1a = weighted SI1 (observations more than two standard deviations from the mean are given 0 weights),
8. S2 = five-term moving average of SI1a for each month (second seasonal estimate),
9. SA1 = NP/S2 (first estimate of seasonally adjusted series), and
10. T2 = 13-term moving average of SA1 (second trend estimate).

For two more iterations, use NP and T2 to redo steps 3 to 10.



APPENDIX 2: SUPPLEMENTARY TABLES

Table 22—Integration of nominal prices into trend, seasonal, and irregular factors, 1960 and 1984

Year	Month	NP	=	T	×	S	×	I
1960	1	21.69		24.21		0.9068		0.9879
1960	2	23.79		25.03		0.9391		1.0121
1960	3	24.42		25.90		0.9505		0.9920
1960	4	26.47		26.80		0.9874		1.0005
1960	5	27.83		27.65		1.0147		0.9918
1960	6	29.97		28.08		1.0466		1.0196
1960	7	30.33		27.87		1.0782		1.0095
1960	8	28.41		26.99		1.0447		1.0076
1960	9	25.59		25.81		1.0064		0.9850
1960	10	24.65		24.72		1.0042		0.9929
1960	11	21.98		24.02		1.0289		0.8893
1960	12	23.56		23.78		0.9916		0.9990
1984	1	246.90		258.72		0.9329		1.0230
1984	2	264.80		260.48		0.9915		1.0253
1984	3	264.25		260.85		1.0319		0.9817
1984	4	280.20		261.86		1.0741		0.9962
1984	5	286.60		268.08		1.0723		0.9970
1984	6	282.80		281.69		1.0231		0.9812
1984	7	286.00		297.69		0.9563		1.0046
1984	8	302.00		308.49		0.9580		1.0218
1984	9	296.00		311.49		0.9364		1.0148
1984	10	313.00		309.74		1.0171		0.9935
1984	11	305.00		307.98		1.0247		0.9664
1984	12	310.00		306.73		0.9814		1.0298

Notes: NP is nominal price, T is the trend factor, S is the seasonal factor, and I is the irregular factor.

Table 23—Correlation coefficients of interdistrict aus rice prices, 1976-82

District	2	3	4	5	6	7	8	9	10
Barisal (2)	1.000	0.925	0.849	0.918	0.987*	0.996*	0.994*	0.976*	
Bogra (3)		1.000	0.884	0.955*	0.901	0.915	0.906	0.875	
Chittagong (4)			1.000	0.979	0.835*	0.884	0.874	0.906	
Chittagong Hill Tract (5)				1.000	0.909	0.935*	0.929	0.934*	
Comilla (6)					1.000	0.984*	0.992*	0.971*	
Dhaka (7)						1.000	0.998*	0.992*	
Dinajpur (8)							1.000	0.991*	
Faridpur (9)								1.000	
Jessore (10)	0.987*	0.947*	0.992	0.967*	0.969*	0.993*	0.988*	0.983	1.000
Khulna (11)	0.996*	0.922	0.869	0.932	0.995*	0.996*	0.998*	0.983*	
Kishoregarij (12)	0.972*	0.920*	0.821	0.905*	0.997	0.982*	0.988*	0.955*	
Kushtia (13)	0.972*	0.920	0.820	0.905	0.997*	0.981*	0.987*	0.959*	
Mymensingh (14)	0.979*	0.947*	0.784	0.882	0.953*	0.958*	0.953*	0.912	
Noakhali (15)	0.996*	0.924	0.873	0.932	0.988*	0.988*	0.988*	0.985	
Pabna (16)	0.980*	0.922	0.927	0.958*	0.957*	0.992*	0.985*	0.989*	
Patuakhali (17)	0.989*	0.958*	0.914	0.965*	0.972*	0.992*	0.987*	0.977*	
Rajshahi (18)	0.925	0.999*	0.871	0.950	0.907	0.912	0.907	0.871	
Rangpur (19)	0.967*	0.970*	0.820*	0.918	0.964*	0.949*	0.951*	0.908	
Sylhet (20)	0.972*	0.986*	0.889	0.957*	0.944*	0.965*	0.957*	0.933	0.982*
Tangail (21)	0.986*	0.975*	0.868	0.944*	0.967*	0.976*	0.972*	0.944	0.984*

Table 24—Correlation coefficients of interdistrict aman rice prices, 1976-82

District	2	3	4	5	6	7	8	9	10
Barisal (2)	1.000	0.965*	0.653	0.734	0.608	0.578	0.975*	0.546	0.813
Bogra (3)		1.000	0.812	0.869	0.780	0.758	0.909*	0.724	0.933*
Chittagong (4)			1.000	0.993*	0.995*	0.991*	0.496*	0.930*	0.960*
Chittagong Hill Tract (5)				1.000	0.983*	0.975*	0.587	0.922*	0.981*
Comilla (6)					1.000	0.999*	0.451*	0.937*	0.941*
Dhaka (7)						1.000	0.420	0.934*	0.941*
Dinajpur (8)							1.000	0.400	0.701
Faridpur (9)								1.000	0.400
Jessore (10)									1.000
Khulna (11)	0.857	0.958*	0.935*	0.964*	0.922*	0.909*	0.758	0.845	0.996
Kishoregarij (12)	0.779	0.907*	0.978*	0.993*	0.971*	0.961*	0.652	0.898*	0.996*
Kushtia (13)	0.781	0.910*	0.976*	0.990*	0.968*	0.960*	0.657*	0.891*	0.997*
Mymensingh (14)	0.832	0.939*	0.962*	0.985*	0.946*	0.934*	0.713	0.870	0.997
Noakhali (15)	0.649	0.811	0.999*	0.992*	0.997*	0.994*	0.494*	0.943*	0.963*
Pabna (16)	0.672	0.832	0.991*	0.986*	0.991*	0.994*	0.494	0.943*	0.963*
Patuakhali (17)	0.999*	0.969*	0.656	0.735	0.611	0.582	0.977*	0.562	0.818
Rajshahi (18)	0.908*	0.983*	0.880*	0.926*	0.864	0.845	0.833	0.814	0.974
Rangpur (19)	0.877	0.969*	0.892*	0.932*	0.884*	0.869	0.801	0.818	0.982*
Sylhet (20)	0.684	0.841	0.989*	0.990*	0.993*	0.987	0.545	0.932*	0.978
Tangail (21)	0.586	0.760	0.994*	0.976*	0.996*	0.997*	0.422	0.917*	0.939

11	12	13	14	15	16	17	18	19	20	21
0.998	0.991	0.970	0.955	0.992	0.996	0.999	0.943	0.995		
1.000	0.984*	0.994*	0.963*	0.998*	0.979*	0.989*	0.924*	0.966*		
	1.000	0.979*	0.984*	0.988*	0.978*	0.995*	0.969*	0.982*		
		1.000	0.974*	0.989*	0.954*	0.975*	0.927*	0.980*		
			1.000	0.969*	0.937*	0.965*	0.940*	0.982*		
				1.000	0.987*	0.993*	0.923*	0.961*		
					1.000	0.993*	0.914	0.927		
						1.000	0.952*	0.965*		
							1.000	0.977*		
								1.000		
0.965*	0.996*	0.950*	0.978*	0.971*	0.967*	0.988*	0.983*	0.979*	1.000	0.996*
0.980*	0.999*	0.980*	0.988*	0.983*	0.968*	0.990*	0.975*	0.989		1.000

* This number is significant at the 0.01 level.

11	12	13	14	15	16	17	18	19	20
1.000	0.987*	0.989*	0.995*	0.937	0.954*	0.861	0.987*	0.992*	0.957*
	1.000	0.999*	0.995*	0.978*	0.985*	0.782	0.957*	0.966*	0.990*
		1.000	0.996*	0.977*	0.987*	0.784	0.956*	0.967*	0.971*
			1.000	0.960*	0.969*	0.833	0.972*	0.976*	0.971
				1.000	0.993*	0.652	0.897*	0.919*	0.992*
					1.000	0.674	0.890*	0.919*	0.992*
						1.000	0.916*	0.886*	0.690
							1.000	0.996*	0.915*
								1.000	0.930*
									1.000
0.908*	0.960*	0.960*	0.936	0.993*	0.991*	0.585	0.839	0.861	0.981*

*This number is significant at the 0.01 level.

Table 25—Estimates for rice markets using the simultaneous system of equations, 1960-84

Equations and Variables	Coefficients	t-Ratio
Demand equation (22)		
Constant	185.99	11.11
Y_{t-1}	-	0.79
PR_t	-1.61	-3.25
SW_t	-4.21	-5.13
Procurement equation (24)		
Constant	-1.11	-0.16
QR_t	-0.02	-0.92
ADP_t	0.38	1.33
OS_t	0.38	0.75
PR_t	-0.16	-0.79
Public distribution equation (25)		
Constant	-3.63	-0.48
PR_t	0.09	0.52
$ADPR_t$	0.06	0.36
Z_t	0.66	3.80
Import equation (28)		
Constant	10.34	5.65
GAP	0.00	2.36
FA	0.01	4.57
WP	-0.03	-0.28

Table 26—Selected data for 1976-84 used in the analysis of rice price stabilization

Year	Nominal Price of Rice	Deflated Price of Rice	Weighted Ration Price	Deflated Ration Price	Procurement Price	Deflated Procurement Price
(Tk/maund)						
1976	110.02	28.07	80.60	20.56	120.0	30.61
1977	139.00	32.18	77.20	17.87	134.0	31.02
1978	144.92	32.28	87.30	19.44	136.0	30.29
1979	204.71	37.63	98.70	18.14	165.0	30.33
1980	168.86	27.91	115.50	19.09	170.0	28.10
1981	216.31	32.38	137.70	20.61	191.0	28.59
1982	239.61	32.34	154.30	20.82	210.0	28.34
1983	257.23	32.64	168.70	21.41	225.0	28.55
1984	286.00	33.49	170.50	19.96	248.0	29.04

Year	Rice Production	Wheat Production	Opening Stock of Rice	Rice Imports	Public Distribution	Procurement of Rice	Previous Year's GNP	F.O.B. Price	GNP in Real Terms
(1,000 metric tons)				(Tk million)			(US\$/ton)	(Tk million)	
1976	13,003	203	800	819	1,216	313	107,602	220.40	29,724.3
1977	12,549	308	373	1,634	1,557	541	105,816	247.85	25,935.3
1978	13,553	438	597	1,134	1,483	317	131,516	311.80	29,487.9
1979	12,250	728	209	2,979	1,784	226	146,610	339.95	28,917.2
1980	14,292	968	791	1,059	1,123	841	178,337	278.09	33,025.3
1981	14,140	857	1,239	1,229	1,344	287	201,849	301.14	33,144.3
1982	14,181	970	578	1,844	1,190	168	225,886	242.25	35,130.1
1983	15,265	1,073	793	2,135	1,205	145	263,721	175.00	35,304.0
1984	14,473	1,296	631	2,575	1,327	133	304,250	171.00	34,771.4

Source: Bangladesh, Bureau of Statistics, *Yearbook of Statistics*, various issues.

Note: Prices are for the coarse variety of rice.

APPENDIX 3: MODIFICATIONS NECESSARY FOR APPLICATION OF THE PROCEDURE FOR SELECTION OF TARGET PRICES IN FUTURE YEARS AND FOR ADJUSTMENT TO LONG-RUN PRICE MANAGEMENT

This supplement aims to clarify two points: (1) What changes in estimation of normal or trend prices are necessary for the selection of target prices after 1984/85? (2) What procedure is appropriate to make the short-run stabilization procedure described in this paper consistent with any future need to realign rice prices in a desirable long-run direction?

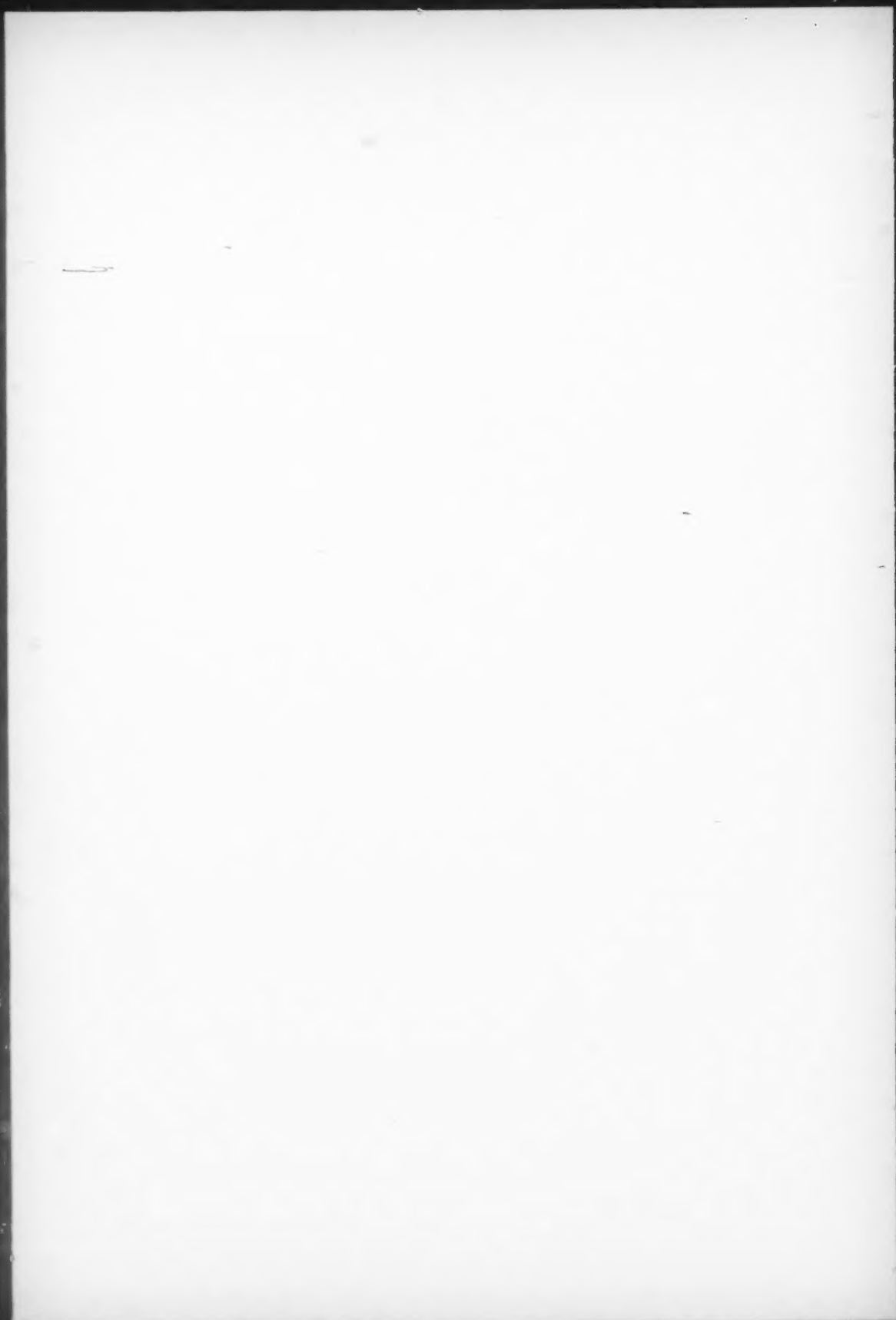
Although the hypothetical case described below is not applicable to Bangladesh, where domestic prices are slightly higher than the world price even assuming a 25 percent overvaluation of Bangladesh's exchange rate, the procedure is described here for those who wish to adapt the methodology to other country situations.

Modification for Future Target Prices

In the simulation for 1976/77-1984/85 a trend line estimate of prices is used based on 1968/69-1984/85 price series (excluding crisis years of 1973/74 and 1974/75). For future years, say for 1985/86, the extrapolation of the trend would provide the normal price for that year. But for 1986/87, the trend should be reestimated by dropping 1968/69 and including 1985/86—the latest year of available data. This trend then would be extrapolated for 1986/87. For each coming year thereafter, the trend line should be reestimated, dropping one year at the beginning and including the latest year at the end of the price series.

Modification for Adjusting Prices for the Long Run

It is clear from the discussion that the concept of "normal price" has been adopted here as a reference for selection of the target annual price by comparing it with the predicted price. If this normal price is judged to be very low in comparison with, say, world price, due to accumulated past distortions, what changes in the procedure are necessary to allow the correction of this past distortion through the selection of annual target prices? Suppose that in year 1984/85 the normal price is lower than the world price (or the long-run desirable level of rice price) by 15 percent, and it is decided that this distortion should be corrected in three consecutive years, for example in 1985/86, 1986/87, and 1987/88. Assuming that this distribution of accumulated distortions implies an increase of Tk 15 per maund each year over the initial target annual prices based on trend and predicted prices, the final target annual price would then be equal to each initial estimate of target annual price plus Tk 15. This upward adjustment in target prices would of course imply a larger volume of procurement and a smaller volume of public distribution and imports than would be the case without the adjustment to world prices, unless import and administered prices are also adjusted in a consistent manner. Adjustment in import and administered prices also implies a change in predicted price.



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NONTRADITIONAL EXPORT CROPS IN GUATEMALA: EFFECTS ON PRODUCTION, INCOME, AND NUTRITION

Joachim von Braun
David Hotchkiss
Maarten Inmink

May 1989

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**Joachim von Braun
David Hotchkiss
Maarten Immink**

**Research Report 73
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in collaboration with the
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FOREWORD

Modernization of traditional agriculture entails increased participation of the smallholder sector in the exchange economy. The achievement of this participation requires an open trade regime, domestic policies that ensure against market failures, and public policy that effectively permits use of new production technology for sustained growth. To open up these opportunities to small farmers, investment in rural infrastructure is essential, as is investment in education that will enable these farmers to participate as entrepreneurs in the growth process. In order to reach out to the landless and land-scarce households, the growth process must stimulate employment and increased returns to land. Nontraditional vegetables for export have a high labor content and therefore promise to help foster rural modernization.

In this study of nontraditional export crops and traditional smallholder agriculture in Guatemala, Joachim von Braun, David Hotchkiss, and Maarten Immink highlight the potentials and risks of export orientation in smallholder agriculture for food security. The policy implications of the report reach far beyond the study area in Central America. The multidisciplinary team of IFPRI and the Institute of Nutrition of Central America and Panama (INCAP) has gone far toward tracing the critical linkages between economic development and nutritional improvement. Two lessons of the study are of critical importance for policy. First, growth in staple food production, stimulated jointly with diversification into nontraditional crops, is necessary to actually capture the gains from specialization in typically risky market environments. Second, joint operation and development of the health and sanitation infrastructure in rural areas is required in order to translate the growth effects into nutritional welfare effects for the poor.

This study, which is a component of IFPRI's ongoing research effort in the field of commercialization of agriculture for food security and poverty alleviation, provides evidence that the income and employment effects of cash cropping can be considerable and, if accompanied by appropriate public policy, can make a major contribution to eliminating hunger and malnutrition.

John W. Mellor

Washington, D.C.
May 1989

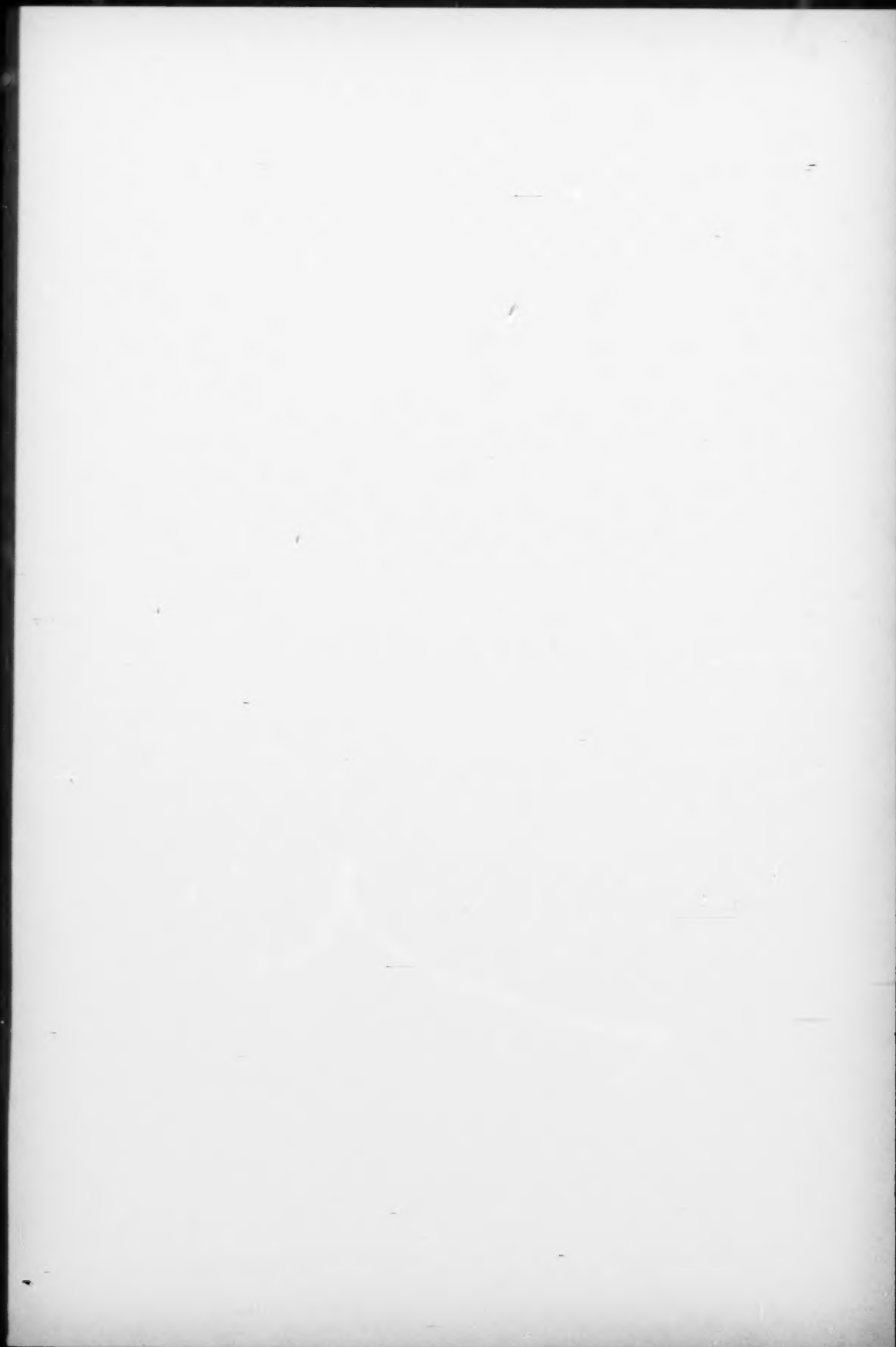
IN MEMORIAM—VICTOR VALVERDE

This research project was jointly designed and its first phase jointly directed with Victor Valverde of INCAP, whose unexpected death in June 1986 came as a shock to his friends and colleagues. This project is one of many research activities stimulated by Victor to improve the understanding of poor people's living conditions and especially of their nutritional situation.

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SUMMARY

Increasing foreign exchange problems and deteriorating prices of traditional export commodities are leading agricultural policymakers to seek diversification in export crop production. Export vegetables, which are nontraditional crops, appear to be a promising option because of their high labor intensity and expanding demand in industrialized countries. This study deals with a case of export vegetable production and its effects on food production, employment, consumption, and nutrition in Guatemala.

Guatemala's agriculture has shifted away from food production to agroindustrial crops. Food crops covered 58 percent of the country's crop area in 1950 compared with 37 percent in 1979. Small farms decreased their basic food crop area from 97 percent to 87 percent in this period.

The focus of this study is the recent introduction of labor-intensive production of vegetables for export in the traditional small-farm sector in the Western Highlands—an area well known for its problems of poverty and malnutrition. Besides considerable research on the "cash cropping-nutrition" issue, the study provides both cross-sectional and longitudinal analyses of effects. The research is based upon two detailed rural household surveys (400 families) that were undertaken in 1983 and 1985. The sample is divided into two groups of households—those who produce the new export vegetables (snow peas, broccoli, cauliflower, and parsley) under a cooperative scheme and those who do not. Differences in duration of participation (one to seven years) in the export crop scheme—the Cuatro Pinos cooperative—characterize the subsample of the export crop growers.

The new export vegetables were rapidly adopted by the smallest farmers (average 0.7 hectare). The model analysis in the study shows that in the early phase of adoption, small farmers with somewhat larger holdings (1-2 hectares) and households that had no reasonably well secured off-farm income source showed a significantly higher probability of adoption. Access to good roads and infrastructure also increased adoption rates.

The new vegetables have certain risks for the small farmers due to possible crop failures, price collapses on the export market, or a breakdown of the marketing institutions. Relative production variability of the new crops is not higher than in the traditional crops, but because the new crops are much more input-intensive the potential loss relative to household income is higher than for the traditional crops. The price variability of the new crops—especially of snow peas, the most important one of them—is extreme. In 1985, prices fluctuated between 0.10 and 2.00 quetzals per pound, but farmers can partially cope with this variability by spreading the growing seasons and having a long harvest period (12 weeks). Recently, in addition to a multinational company and the cooperative, other traders have handled the export channel. Also, local processing and freezing of fresh produce have been initiated. These developments reduce the risk of a sudden collapse of the marketing channel.

Nontraditional export crops are substantially more profitable to farmers than traditional crops. Net returns (gross margins) per unit of land of snow peas are on average 15 times those of maize—the most important traditional crop. Returns of the new crops per unit of family labor were about twice as high as for maize and 60 percent higher than for traditional vegetables produced for local markets in 1985. The input costs per hectare for snow peas, however, are on average about 4 times higher than

for traditional vegetables and 13 times higher than for maize. Short-term financing of inputs poses a problem to small farmers and indicates the importance of rural credit.

Farm households outside the cooperative grow traditional subsistence crops (maize and beans) on 78 percent of their land, whereas participants in the scheme grow those crops on 52 percent of their land. The smallest cooperative farms allocate the highest shares of land to the new export crops.

Nevertheless, most export crop producers tend to have higher amounts of maize available (per capita) for consumption from own produce than other farmers of the same farm size, because cooperative members' maize and bean yields are 30 percent higher on average than nonmembers' yields. A combination of factors is responsible for this increase in yields; fertilizer inputs are increased and cropping practices are more labor-intensive (more weeding labor). Farmers with the most school education were found to have even higher yields at given input levels.

Analysis with the help of a consistent farm household model based on the survey data shows that with new export crops the shadow cost of maize produced for own consumption increased drastically. The difference between the shadow cost and the actual market price (0.29 quetzal in 1985) may be interpreted as an "insurance premium" that farmers are willing to pay for the degree of self-sufficiency they actually maintain.

Nontraditional export crops created local employment directly on farms and indirectly through forward and backward linkages and multiplier effects resulting from increased income spent locally. Combining farm-level employment with the roughly estimated employment created through the input supply and output marketing yields an overall 21 percent increase in agricultural employment in the six communities where the cooperative functions. Labor input in agriculture increased by 45 percent on the farms producing export vegetables. About half of this increase is due to family labor and half to hired labor. A substantial share of the incremental increase in family labor is from women and children. As a consequence of increased on-farm employment, off-farm work and interregional migration of members of export vegetable producers' households are found to be reduced.

The export crop production scheme led to increased income in the participants' households. This increase between the two surveys (1983-1985) was most pronounced in the group of new adopters, in which expenditures—used as an income proxy—increased by 33 percent. The income gains were highest among the adopters on the smallest farms, thus the new export crops had a favorable effect of moving the poorest upward on the income scale.

At same-income levels, export crop-producing farm households spend less of their additional income on food than traditional-crop households. While nonmembers in the lowest quartile on the income scale spend 61 percent of additional income on food, cooperative members in the same income class spend 53 percent. Additional income increases calorie acquisition significantly but at decreasing rates at the margin. Member households in the lowest half of the income scale increase their calorie consumption by 2.8 percent with a 10 percent increase in income, while nonmember households increase theirs by 4.4 percent.

The production- and income-related analysis concluded with favorable effects of the nontraditional crops for food crop productivity, employment, income growth, and income distribution. The expenditure and food consumption analysis found that incremental income earned from the nontraditional crops tends—at same-income levels—to be spent relatively less on food than other income; this is also reflected, although to a lesser extent, in calorie availability. Thus, food expenditures and consumption increased relatively less than expected. Improvement in the nutritional status of children,

most significantly in decreased wasting, is associated with increased income and food consumption in export crop-producing households. The nutritional benefits of economic growth, as shown in this study, are substantial but can be further enhanced by appropriate health- and nutrition-oriented social infrastructure. The effects of health programs conducted by the export crop cooperative in participating communities support this conclusion.

Especially in the late 1970s and early 1980s, steps to alleviate poverty and improve living conditions in Guatemala were constrained by the economic and political environment. The case study shows, however, that with appropriate access to resources and markets and effective assistance in institution-building at the community level, the poor in the Western Highlands can substantially improve their income and welfare.

THE RESEARCH ISSUES AND APPROACH

Commercialization of Traditional Agriculture

An increasing number of low-income countries are facing crucial strategic decisions on how to cope with short- and long-run food security problems. At the core of these strategic decisions is the appropriate choice of policies to promote production of export crops, cash crops for the domestic market (food and nonfood), and subsistence food crops.

Many developing countries are encouraging the increased production of export crops as a way to generate foreign-exchange earnings and fiscal revenues, to increase the income of small landholders, and to provide employment for the rural poor. However, critics of policies that advocate cash crop production argue that the potential benefits have never materialized and, more important, that in areas where cash crop production has increased, food consumption and the nutritional status of the poorest households have deteriorated. A comprehensive review of the existing literature and earlier research on the issue shows mixed results (Braun and Kennedy 1986). This is not surprising, given the great variety of cash crops and production conditions in general.

In developing countries, increased market integration of semisubsistence agriculture appears unavoidable. Rapid urbanization, growth of the rural nonagricultural sector, and technological change in agricultural production are the major driving forces of this commercialization process. Urbanization without increased rural-urban market integration would lead to volatile dualistic structures and import dependence.

On the basis of existing research, it is evident that critical relationships that determine food consumption and nutrition are affected by increased commercialization. These effects may be positive or negative. At the macroeconomic level, an issue of concern is whether foreign exchange generated through export cropping is actually used for imports of goods and services that improve the food consumption and nutritional situation of the poor. Foreign-exchange regulations and taxation of export crops, along with import controls by governments, may lead to distortions that prevent the poor, including small farmers in the export sector and other rural households, from having access to the direct and indirect benefits of the specialization.

This study concentrates mainly on the household-level effects of cash cropping in rural areas. At this micro level the outcome depends on changes in real income, income distribution, income composition, and income control (by men or women). How do these factors translate into household food consumption? What are the effects on time allocation (especially for mothers), and on health and sanitary factors? At this point, no clear ranking of factors is possible on the basis of existing research. A number of studies show, however, that the positive effect of increased cash income on calorie consumption may be quite small, even among the poor.¹ This may be a result of changes in income composition and income control within the household.

A crucial question for policy and program design is whether potential adverse effects of increased cash cropping on nutrition are actually observed and, if so, whether they are of a short- or long-term nature. This is not to say that short-term effects for one to

¹ See the review in von Braun and Kennedy 1986, 55-59.

two years should not be an issue of concern. But appropriate and efficient policy measures to balance potential adverse effects are dependent on the time frame of the problem. Whereas short-term problems may be dealt with mainly by adjustments in the timing of project implementation and a combination of measures such as temporary income support, price subsidies, and nutrition education, long-term adverse effects require very different policy instruments that have the potential to improve and stabilize living conditions for the losers in the commercialization process. Employment generation in rural areas would be a major element of these policies.

The uneasiness about the above-mentioned critical relationships between agricultural production and nutrition in the commercialization process suggested a series of detailed studies that are being executed at IFPRI in collaboration with other institutions.

Theoretical Approach and Concept

This study on the commercialization of smallholder agriculture in Guatemala looks into the introduction of nontraditional vegetables for export. It was clear at the outset that this change had substantial effects on agricultural production and employment in the study area. The order of magnitude of these effects and the effects on income, consumption, and nutrition, however, were not clear at all. The precise concern was that expansion of a crop for export in an area with a well-known nutrition problem might have adverse effects on the availability and security of food and might further aggravate the nutrition problem. If the export crop scheme increased employment and income of the poor, a related issue that stimulated the research was the provision of background understanding needed to ensure rapid translation of income growth into improved physical welfare, especially nutrition, in the households.

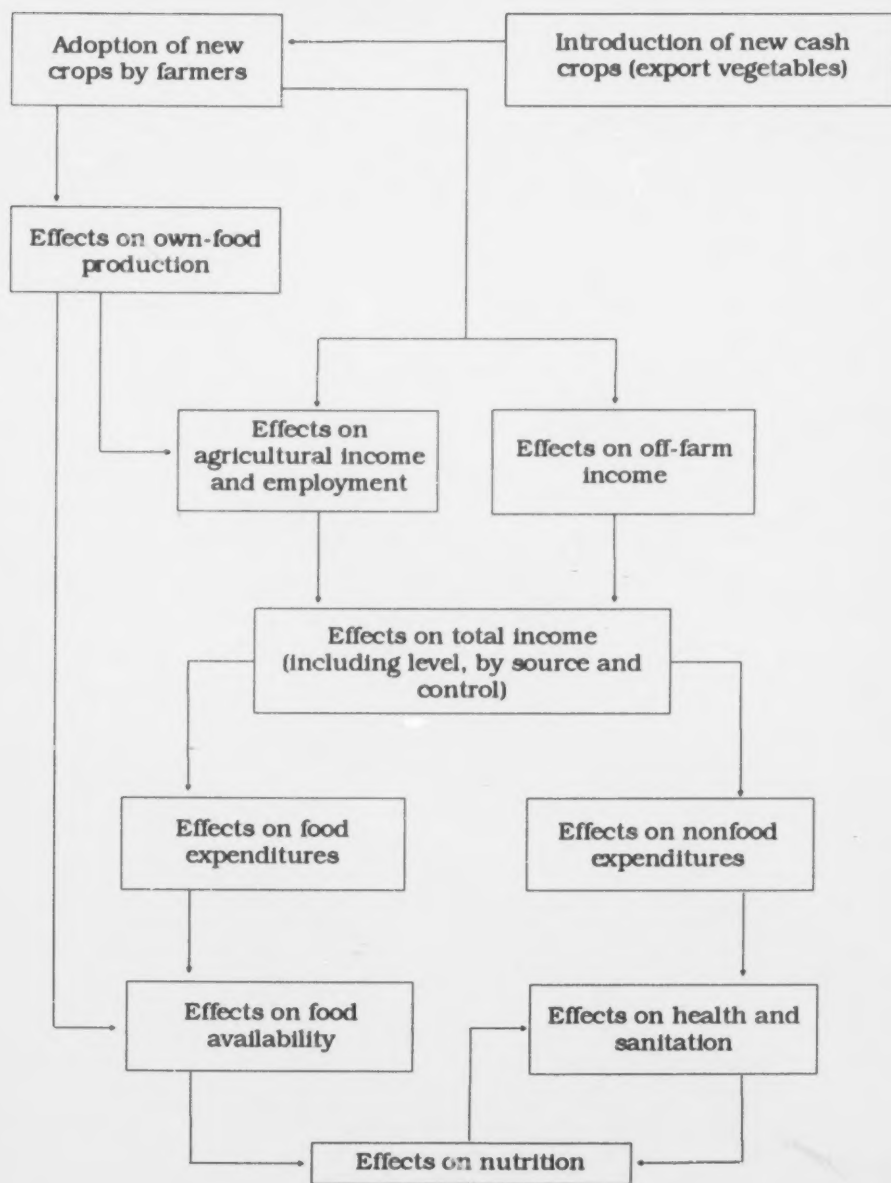
The theoretical concept of the household-level analysis of commercialization effects takes a disaggregated approach to tracing the consequences for different types of households and different groups inside the households. It is not *a priori* assumed here that incremental employment and income from the new crops leaves household utility functions unchanged. It is now widely recognized that farm households are not necessarily homogeneous units of decisionmaking.² Profound changes in the opportunities for income earning on the farm—be it through new technology or new market outlets—may have profound implications for division of labor and for relative control of income shares, which may change budget allocations within the household beyond the pure income effect. This study attempts to trace such effects and to quantify their impact on the consumption and nutrition effects of increased commercialization of traditional agriculture. Understanding these relationships is crucial to identifying policy options that avoid adverse effects of commercialization on consumption and nutrition in poor households and enhance positive ones.

The research focuses on the effects of the commercialization process on household-level food security. Food security, in this context, is understood in the broad sense as the ability of households and their members to acquire sufficient quantities of food over time, whether from own produce or from the market. Related to this, the effects of change in commercialization on the actual nutritional situation of children is assessed. The main relationships studied in this evaluation of increased commercialization are its effects on agricultural production (especially food) and on employment and income (on-farm, off-farm), and the extent to which these translate into effects on food and

² See Folbre 1986 and the literature quoted therein.

nonfood expenditures, food consumption, and nutrition. Clearly, these issues are related to each other. A simplified overview of the relationships as affected by commercialization at the household level is provided in Figure 1. This figure also provides an overview of the steps of analysis but does not depict the complex dynamics involved.

Figure 1—Flow of analysis for evaluation of household-level effects of the commercialization process



Overview of the Report

The commercialization process at the micro farm-household level should be understood in the context of the macroeconomic environment and its political economy. A review of commercialization of Guatemala's agriculture is provided at the outset. The introduction of new cash crops is evaluated in its institutional context. This requires a focus on the actual making and operating of the commercialization process; success or failure of a program is largely determined in this sphere, which is much underresearched. Therefore, those who play a role in commercialization are examined before the household-level effects are evaluated.

At the farm-household level, the process and determinants of adoption of the new crops are evaluated. The main questions addressed are who are the (early) adopters and what are their characteristics? In the context of this case study, this leads directly into the issue of competition and complementarity between nontraditional and traditional crops, on-farm and off-farm labor supply, and division of labor in the households. How is food availability from own production affected? Where does the increased labor input on the farm stem from? Who in the household controls the incremental farm income?

From the income effects, the effects for household resource allocation to food and nonfood expenditures are traced. Special focus is on food expenditures and food (calorie) availability. What share of incremental expenditure in export crop-producing households versus other households at same-income levels is spent on food and what types of food? To what extent is food availability in terms of calories improved?

Finally, these effects are traced to the nutritional status of children in the households. How is nutritional status—measured in anthropometric terms (weight, height-for-age)—affected by changes in food availability and the health and sanitation environment of the households?

The study concludes with lessons for policy from this particular case and an attempt to identify generalizable findings.

Survey Methods and Data

The household-level data of this research are based on representative surveys undertaken in 1983 and 1985 in the six villages where the Cuatro Pinos cooperative was active. The sample is based on a census in the villages done in 1983 (INCAP 1985). A roughly equal number of members of the cooperative ($n = 195$)—that is, growers of the new export crops—and nonmembers ($n = 204$) were drawn at random by village from the census information. To ensure a reasonable coverage in the smaller villages, the sample was biased toward the four smallest communities among the six villages. This brings the sample closer to the prevailing village pattern in the Western Highlands. The proportional adjustments of the sample by village size led to a coverage of 38-75 percent of the cooperative members in each community (average, 47 percent) and 8-17 percent of nonmember households (average, 11 percent) in these communities (Table 1).

The same households were surveyed in 1983 and 1985. They were visited between November and January of 1983/84 and 1985/86. Conducting both surveys during the same time of the year avoids the seasonality effects that might disturb comparisons between the two rounds.³

³ Seasonality in food consumption, however, does not appear to be very pronounced in Guatemala. See Valverde et al. 1985b.

Table 1—Village-level information: sampling in 1983 and 1985

Category	San Matéo	El Rejón	Santa María Cauqué	Pacul	Pachali	Santiago	Total
Size of village (number of households, 1983)	195	180	445	95	141	1,250	2,306
Cooperative member households, 1983	21	15	65	32	38	248	419
Nonmember households, 1983	174	165	380	63	103	1,002	1,887
1983 sample							
Cooperative members	13	10	36	24	18	94	195
Sample population as percent of total ^a	(62)	(67)	(55)	(75)	(47)	(38)	(47)
Nonmembers	29	27	32	11	18	87	204
Sample population as percent of total ^a	(17)	(16)	(8)	(17)	(17)	(9)	(11)
1985 sample							
Cooperative members	12	15	31	20	17	84	179
Nonmembers (farmers and non-farmers)	28	23	37	14	20	100	222
Nonmembers (farmers)	24	23	34	12	16	70	179
Years of cooperative membership in 1985							
Less than 3	5	15	3	7	1	19	50
3-4	7	...	14	4	9	19	53
5-7	...	...	14	9	7	46	76

Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a The percent figures in parentheses represent the percentage of total population covered in the communities by the sample survey.

The composition of the 1985 sample is affected by changes in household characteristics since the 1983 survey. Some households split when the younger generation started its own households, some cooperative members dropped out of the cooperative, and some nonmembers became members. Also, some households could no longer be interviewed because of long-term absence. Between 1983 and 1985, 9 percent of the member sample left the cooperative and 6 percent of the nonmember sample became members. Taking the stratification of the sample into account, these numbers suggest a net increase of members by 19 percent since 1983. This roughly corresponds to the actual change in the membership statistics of the cooperative between 1983 and 1985.

The sample is spread over early and late adopters. Forty-two percent of the sampled households of the cooperative members have been in the scheme for as long as five to seven years. Newcomers are spread over all six communities, while the early adopters are all in the four founding villages of the cooperative (see Table 1).

The field data collection for the 1983 and 1985 surveys was done by the experienced survey staff of the Institute of Nutrition of Central America and Panama (INCAP).

The household-level information collected includes

1. demographics of the household (employment, schooling);
2. health, anthropometrics of children under 10 years of age, and child-feeding practices;
3. housing conditions;
4. access to services;
5. nonfarm income (by individual, by source);
6. agricultural production (inputs, outputs, labor at field level by crop, size of fields, produce sales, input purchases, animal production, land quality);
7. food expenditures and consumption of own-produced food; and
8. nonfood expenditures.

The various types of information are covered over recall periods specific to the nature of the data. Agricultural production covers the crop years 1982/83 and 1984/85 (May-April), and off-farm income covers the 12 months preceding the surveys (November-October 1982-83 and 1984-85). Food and nonfood expenditures are monthly (October 1983, October 1985), with an annual recall for lump sum nonfood expenditures (especially durable goods) added to the 1985 survey that covers November 1984 to October 1985.

In a subsample of the 1985 survey consisting of 40 households in two communities (El Rejón and Santiago de Sacatepéquez), a detailed assessment of intrahousehold decisionmaking and of sexual division of labor and time allocation of household members was undertaken parallel to the large survey (Nieves 1987).

COMMERCIALIZATION OF GUATEMALA'S AGRICULTURE

Guatemala is the third largest in area of the Central American republics, after Nicaragua and Honduras, but its population of about 8.4 million (1984 figure) exceeds that of the latter two countries combined. About two-thirds of the population lives in rural areas; around 60 percent of them are indigenous people who are descendants of the Maya. The indigenous population is mainly concentrated in the Western Highlands of Guatemala where this study was conducted.

The agricultural sector provides about 50 percent of the country's employment and accounts for 25 percent of the gross domestic product (GDP) in the mid-1980s. Agricultural exports hold a share of about 65 percent in total merchandise exports, thus making agriculture the primary foreign-exchange earner of the economy.

Guatemala's highly dualistic agricultural structure is well documented.⁴ A modern, export-oriented, large-scale farm sector and a traditional, subsistence-oriented, small-scale sector have long coexisted. The two sectors are not independent but rather are closely linked through the rural labor market. Labor from the traditional sector in the Western Highlands (a sector operating on an agricultural-resource base per household that in most cases cannot support the bare survival requirements of the family) seeks employment through interregional migration either to the areas of the large-scale export crop sector—mainly in the lower altitude regions—or, in recent decades, to the urban services sector.

This pattern of export crop production and its interaction with the subsistence farm sector has been in existence for decades. Its effects on the subsistence farm sector are substantial (Schmid 1968, 33-45). Yet the focus of this research is not to study these indirect effects but the recent changes in the subsistence sector itself, namely, those resulting from the shift into export crop production by small farmers in the Western Highlands. The traditional dualistic pattern of subsistence and export crop sectors, however, must be kept in perspective to assess the implications of the change in commercialization in the small-farm sector. Clearly, this subsector—though mainly subsistence-oriented in crop production—was already "commercialized" by selling a high share of its labor rather than its crops.

Exports from a Dualistic Agricultural Sector

Agricultural exports from Guatemala may be grouped into traditional and nontraditional exports. The traditional ones in their order of share in total agricultural exports are coffee, cotton, sugar, bananas, and beef. These crops account for 76 percent of agricultural exports in the mid-1980s (Table 2). Among the important nontraditional agricultural exports that account for the remaining 24 percent are cardamom, vegetables, flowers and plants, fruits, and sesame seed. Since the mid-1970s the share of agricultural exports in total merchandise exports has remained stable, but the composition of

⁴ See Nyrop 1983 and the extensive bibliography in this source; also World Bank 1978.

Table 2—Value of agricultural exports from Guatemala, 1975-84

Export Item	1975	1980	1984
	(US\$ million)		
Traditional agricultural exports			
Coffee	164	464	361
Cotton	74	166	72
Sugar	116	69	71
Bananas	35	45	55
Beef	17	29	13
Subtotal	406	773	572
(Percent of total agricultural exports)	(92)	(79)	(76)
Nontraditional agricultural exports			
Cardamom	10	56	100
Vegetables, flowers and plants, fruits	9	68	43
Other ^a	15	75	39
Subtotal	34	199	182
(Percent of total agricultural exports)	(8)	(20)	(24)
Total agricultural exports	440	972	754
Total exports	651	1,520	1,132
(Agricultural exports as percent of total exports)	(67)	(64)	(67)

Source: Based on data from Bank of Guatemala, "Economic Data, 1985" (Bank of Guatemala, Guatemala City, mimeographed).

^a Includes essential oils, fish, gum, honey, cocoa, cotton seed, sesame seed, cotton lint.

agricultural exports has become more diverse. The share of traditional agricultural exports dropped from 92 percent in 1975 to 76 percent in 1984, although traditional exports grew in absolute dollar terms. Increased diversification of the agricultural export sector is a stated policy objective to reduce instability in foreign-exchange earnings due to price fluctuations—for example, of coffee—in international markets (Banco Interamericano de Desarrollo 1986, 74).

Landownership in Guatemala is extremely skewed. The Gini coefficient, which ranges from zero in a situation of perfect equality to 100 in a situation of maximum inequality, was 85.1 for land distribution in Guatemala in 1979—higher than for all other Latin American countries (Hough et al. 1982, 1). The Gini coefficient increased from 82.4 to 85.1 between 1964 and 1979, indicating further inequality (Hough et al. 1982, 2). Two percent of farmers held 67 percent of the agricultural land—land that is generally of better quality than the land cultivated by small farmers.

For those at the bottom of the land distribution, population growth leads to rapid reduction of average farm size. From 1964 to 1979, the average farm size of those under 1.4 hectares (2 *manzanas*) decreased from 1.0 to 0.7 hectare. Sixty percent of Guatemalan farms fall in this group that cultivates 4 percent of the land (Table 3). Most of the subsistence farm households in the Western Highlands also fall in this group; thus, not surprisingly, more than 90 percent of the sample survey households are part of this farm-size class.

Total agricultural land in use increased by 0.8 percent per year between 1950 and 1979. Expansion into new lands did not provide any significant relief for the land constraint burdening the small-farm sector, nor does it provide a potential solution for this problem (Hough et al. 1982). The obvious solution—agrarian reform with redistribution of land from large-scale farms to small farmers—was attempted by governments in the late 1940s and early 1950s, but the attempts were finally blocked when the government was toppled in a coup in 1954 (Kinzer and Schlesinger 1983).

Table 3—Farm-size distribution in Guatemala, 1950, 1964, and 1979

Farm Size (hectares)	Share of Farms			Share of Area		
	1950	1964	1979	1950	1964	1979
	(percent)					
Less than 1.4	47 ^a	44	60	3 ^a	3	4
1.4–3.5	29	31	21	6	7	6
3.5–44.5	22	23	17	19	23	23
44.5 or more	2	2	2	72	67	67
Total	100	100	100	100	100	100

Source: Based on data from SEGEPLAN, *Agricultura, Población, y Empleo en Guatemala* (Guatemala City: SEGEPLAN, 1984).

^a In the 1950 census, farms with less than 0.04 hectare were excluded.

Guatemala's agriculture has continuously and substantially shifted away from staple food production (which includes a large share of subsistence production) to cash crops and production for exports. Basic food crops covered 58.0 percent of agricultural area in 1950 compared with only 37.4 percent in 1979 (Table 4). Cash crops and export crops increased their share in land use from 20.0 to 29.8 percent during the same period. Although this change in cropping patterns mainly took place in the medium-sized farms (3.5–44.5 hectares), the smallest farms are following the same pattern of change. They decreased their basic food crop area from 96.7 to 87.4 percent in this period and increased their area devoted to cash crops.

Since 1979 the area allocated to the major staple foods (maize and beans) has increased somewhat, but yields show a downward trend that has made total staple food production stagnant and reduced the per capita staple food production by a rate of –0.3 percent per year between 1968 and 1982 (FIDA 1985, 57–58).

Table 4—Specialization in crop production, by farm size, 1950, 1964, and 1979

Farm Size (hectares)	Type of Crops ^a	Land Use in Share of Farm-Size Class		
		1950	1964	1979
		(percent)		
Less than 1.4	Basic food crops	96.7	91.1	87.4
	Cash and export crops	3.3	8.5	12.2
	Pasture	...	0.4	0.4
1.4–3.5	Basic food crops	93.5	90.1	84.6
	Cash and export crops	6.2	8.4	14.0
	Pasture	0.3	1.5	1.4
3.5–44.5	Basic food crops	84.8	68.0	64.4
	Cash and export crops	10.8	12.6	19.1
	Pasture	4.4	19.4	16.5
44.5 or more	Basic food crops	18.8	14.4	13.7
	Cash and export crops	35.1	32.1	38.4
	Pasture	46.1	53.5	47.9
Total	Basic food crops	58.0	41.3	37.4
	Cash and export crops	20.0	23.1	29.8
	Pasture	22.0	35.6	32.8

Source: Based on data from SEGEPLAN, *Agricultura, Población, y Empleo en Guatemala* (Guatemala City: SEGEPLAN, 1984).

^a Basic food crops include maize, beans, rice, wheat, potatoes, and traditional vegetables. Cash and export crops include sorghum, cotton, coffee, sugarcane, cardamom, sesame, groundnut, tobacco, rubber, and fruits. Pasture includes permanent pasture and land for fodder crops.

How did overall food availability develop over time against this background of change in production patterns toward exports and the slow growth in domestic food production? Overall per capita staple food availability was stable in the 1960s but declined in the 1970s—from an average of 134 kilograms per capita per year (in wheat equivalent) in 1961-63 to 128 kilograms in 1981-83. In the same period, calories per capita per day increased from 1,937 to 2,080 (FAO, various years). Obviously, relatively more calories come now from nonstaple foods. It should be stressed that such country averages do not really address the food situation properly, especially in countries with such large spreads in income distribution as Guatemala.

Generally, developing countries tend to manage joint growth in the basic food crop and cash crop subsectors or fail to achieve growth in either (von Braun and Kennedy 1986, 27-36). Guatemala, however, appears as an exception to this tendency. Its cash crop sector was growing over the long term while its basic food crop sector stagnated (von Braun and Kennedy 1986, 35). This may be explained by the highly dualistic structure of Guatemala's agricultural sector. This structure does not accommodate positive spillover effects from promotion of traditional export crops through credit, inputs, market infrastructure, and so forth, to the basic food crops, as the two are mainly grown on two very distinct types of farms—large scale versus small scale—as well as in different locations.

The effects of increased commercialization through the introduction of new cash crops for food crop production in the small-farm sector may, however, turn out to be very different from the development path of the isolated expansion of agroindustrial crops in the large-scale farm sector. In principle, positive linkages between new cash crops and the promotion of traditional food crops could be established in this case.

Recent Variations in Agricultural Policy

In the early 1980s Guatemala's substantial export-led economic growth, with low levels of general inflation and an impressively strong currency, experienced a crisis. Between 1982 and 1985, per capita gross national product (GNP) was down by 20.5 percent in real terms (Banco Interamericano de Desarrollo 1986, 5). The Guatemalan quetzal, which was valued at a fixed 1-to-1 rate against the U.S. dollar for more than 40 years, was devalued in 1984 and further devalued in 1985 to about Q3.00-US\$1.00 in the parallel market. A product-specific system that allowed differential access to the parallel-market exchange rate and imposed different shares of the export revenue to be converted at the old 1-to-1 rate has led to numerous variable exchange rates—and implicitly to a host of different export tax levels through exchange-rate regulation. For instance, in early 1986, 25 percent of coffee dollars were to be exchanged at the parallel rate and 75 percent at the official rate. Export vegetable dollars got better treatment by an imposed share of 50 percent at the official rate.

This exchange-rate policy induced equivalent distortions on the import side. A policy of using the foreign exchange acquired through the implicit taxation of exports for importation of so-called essential agricultural imports (such as fertilizer and food) at the old exchange rate was largely ineffective. Fertilizer prices roughly doubled from 1985 to 1986. Thus the input-intensive export crops came under pressure from both sides—export taxation through partly maintained overvalued exchange rates, and the full effect of the devaluation of domestic currency on the input price side. During 1980-84, export values declined faster among traditional export crops (-7.3 percent)

than nontraditional crops (-2.2 percent). On the basis of this experience, the government policy for agriculture, as laid out in the 1984-86 National Development Plan, emphasizes both diversification of export-oriented agricultural production and increased production of food commodities.

The causes of the recent economic crisis must be seen in the context of both the country's violent internal conflicts and the external economic factors, especially the deterioration of terms of trade and substantially higher interest rates for capital investments. In a country with a very small public sector and extremely limited public services for the poor, the economic crisis is assumed to have hit particularly hard the low-income stratum of the population, which in Guatemala is a large proportion of the population.

Poverty in Guatemala is predominantly a rural problem and is particularly concentrated in the Western Highlands. A survey in 1980 classified 36.2 percent of the rural population as absolute poor, as their income was too low to purchase an adequate diet. These rural poor constituted 73.5 percent of all poor. Agricultural income per household in the Western Highlands was about 40 percent below the average of other rural areas in the country (Guatemala 1982).

Evolution of Commercial Agriculture in the Large- and Small-Farm Sectors

The dualistic structure of Guatemala's agriculture, with large-scale farms versus *minifundus* (mainly in the hands of indigenous farmers), is largely an inheritance of the structural change introduced by the Spanish during the colonization of the country (Nyrop 1983). With the introduction of coffee cultivation after the 1840s, much of the best land in the highland departments was absorbed into expanding coffee haciendas. The indigenous population who had been farming these lands for generations were forced to move to higher, less fertile lands in order to continue growing their subsistence crops—maize and beans (Hough et al. 1982, 21-24). This change took place mainly between 1870 and 1920.

Another major export-oriented change with long-term consequences, not only for agriculture but also for the political stability of the country, emerged in the 1920s and 1930s when the United Fruit Company acquired large landholdings—mainly for banana plantations in the fertile lowlands. Concessions to the company by the government totaled about 190,000 hectares (Kinzer and Schlesinger 1983).

The basic effect of the traditional export orientation in Guatemala's agriculture was an increased concentration of land in large farms and of the indigenous population in the remaining high-altitude areas with unfavorable land quality. At times, forced labor obligations were imposed on this population to fill the labor demand in the export crop sector (Nyrop 1983). Through reduction of the land-resource base for the indigenous population, the opportunity cost of labor on their own small holdings was reduced, thus assuring a cheap labor supply to the large-scale farmers.

Technological change in the food crop sector was not exceedingly successful in Guatemala (CGIAR 1984). Growth in yields of maize was 1.6 percent per year between 1971-73 and 1981-83. Only a small surplus of the traditional food crops in the small-farm sector is produced for marketing, so these crops have not become a source of cash income. In the typical Western Highlands situation, about 90 percent of the maize grown is retained for own consumption. It is only recently that maize production has increased on large-scale farms.

Export vegetables, the focus of this study, were introduced to Guatemala in the mid-1970s with substantial foreign investment.⁵ Originally, the scheme operated with an integrated production-processing (screening, packing, cooling) exportation system in the hands of one company. Soon the economic advantage of contract growing in the smallholdings in the Western Highlands became apparent. Company crop production was phased out and farmers in selected villages were awarded contracts. The main commodities were cauliflower, broccoli, snow peas, and brussels sprouts.

This system continues to operate and the farmers of the Cuatro Pinos cooperative, the focus of this research, were part of this contract system in the early 1980s. Kusterer, Estrada, and Cuxil (1981, 6-9) point out the rather different effects of the contract-growing scheme in different locations of its operation. The access to inputs and to restricted delivery for the contracted amounts of outputs was, at various locations, a problem to farmers. In general, farmers were very eager to join the scheme. In fact, a major short-term problem was that farmers had moved unexpectedly fast into production of some of the vegetables and the marketing and export channel did not keep up with this rapid adoption, thus leading to critical frictions between the contract partners in the cooperative (Kusterer, Estrada, and Cuxil 1981, 17-24).

Export vegetable production is done at the individual farm level in the context of contract growing or independently relying on market middlemen, called *coyotes*. A substantial part of the export vegetable production stems from farmers who have formed cooperatives. The positive attitude of Guatemalan peasants toward cooperation in production with households from the same ethnic group is a good basis for agricultural cooperatives (Bossen 1984). In 1984, 812 cooperatives with more than 143,000 members were registered, of which 382 cooperatives were agricultural ones.⁶ More than half of all cooperatives are located in the Western Highlands, the area of this study. Agricultural cooperatives had on average 167 members in 1983—less than half as many as the Cuatro Pinos cooperative had at that time.

⁵ A very comprehensive description and evaluation of the early operation is given in Kusterer, Estrada, and Cuxil 1981.

⁶ Of the 812 cooperatives, 731 were considered actually active at the end of 1983 according to El Instituto Nacional de Cooperativas (INACOP), as stated in FIDA 1985, 137.

INITIATORS AND OPERATORS OF EXPORT CROPPING IN SMALLHOLDER AGRICULTURE: THE CUATRO PINOS COOPERATIVE

Food and agricultural policy plays a key role in shaping the commercialization of traditional agriculture. Commercialization of subsistence agriculture does not simply develop as a result of changes in economic incentives or new technology at the farm level, the processing level, or in marketing. To a large extent, the commercialization process is also influenced and designed by actors at the local level and, especially in case of export crops, by actors who are quite removed from the local farm-production scene. The Cuatro Pinos cooperative is an interesting case in point.

Socioeconomic Environment of Cuatro Pinos at the Outset

Cuatro Pinos is active in six villages in and around the *municipio* (county) Santiago Sacatepéquez, which is located about 35 kilometers west of Guatemala City.⁷ Storage and processing facilities for the export vegetables are in Santiago, which is the base of the cooperative. The community is connected to the paved road of the Pan-American Highway, which is 5 kilometers away. The altitude is around 1,900-2,000 meters.

According to a survey carried out in 1977, 10 percent of the cultivated area of the *municipio* was devoted to the production of different vegetables. The remaining 90 percent was for maize and beans (Hintermeister 1986, 10). Between 10 and 15 percent of family heads living in Santiago were working in Guatemala City. In general, they were relatively young and had access to small parcels of land below subsistence levels.

In one of the main villages in which Cuatro Pinos is operating, Santa María Cauqué, a comprehensive longitudinal study on population, agriculture, nutrition, and health depicts the situation before implementation of the cooperative (Mata 1978). Between 1963 and 1971, the population increased at a rate of 3.1 percent per year, while farm size decreased at a rate of 3.5 percent. Since then, population growth has increased at a rate of 3.5 percent per year. This particular village, however, is a rather untypical case. The trend toward cash crops was established even before the establishment of the cooperative, but the cooperative reinforced the trend. This village was more commercialized at the outset than the other five villages of the cooperative, mainly because of its favorable access to transport and communication infrastructure by virtue of its proximity to the Pan-American Highway. In the 1960s the cropping pattern changed gradually, showing a reduced share of subsistence crops. From the early 1970s to 1985, the share dropped from 70 to 50 percent, corresponding to the increased share of new export crops and traditional vegetables (Table 5).

The incidence of severe protein calorie malnutrition (PCM) was found to be considerable in Santa María Cauqué. In a cohort analysis between 1964 and 1969, 13 percent

⁷ Since 1987, the cooperative has operated in eight villages.

Table 5—Average farm size, population, and land use pattern in Santa María Cauqué, 1963-85

Item	1963	1967	1971	1985
Farm size (hectares)	1.2	1.1	0.9	0.8
Population	1,071	1,254	1,370	2,225 ^a
Land use (percent)				
Maize and beans	78.7	73.2	70.5	49.5
Vegetables and other crops (including export crops)	21.3	26.8	29.5	50.5

Sources: Based on data from L. J. Mata, *The Children of Santa María Cauqué: A Prospective Field Study of Health and Growth* (Cambridge: Massachusetts Institute of Technology Press, 1978), p. 18; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Estimated on the basis of a 1983 census done by the Institute of Nutrition of Central America and Panama.

of 1-year-old children, 27 percent of 2-year-old children, and 9 percent of 3-year-old children were found to be affected by PCM (Mata 1978, 298). Most cases of severe PCM occurred in the rainy season (June-September), when infectious diseases—particularly measles, diarrhea, and respiratory infections—are most frequent. In explaining this pattern of the prevalence of PCM, Mata (1978, 302) concludes that “the relationship of food availability, marketing, and cash to malnutrition deserves serious investigation.”

At the outset, the general socioeconomic environment and health and nutrition situation in the area of the Cuatro Pinos communities appeared to be not particularly different from the general situation in the Western Highlands. Some special features of the economic environment are, however, noteworthy. Closeness to the capital city and the good infrastructure facilitated market integration with fresh vegetables. Average farm size is below the average in the Western Highlands. Also, there are no big farms in the area. This has two implications: there were no serious conflicts over land—at least in the 1970s—and the influence of nonindigenous farmers on the social organization and economic activities in the *municipio* was small. Thus there was neither an important social force to oppose the local development of the cooperative nor landowners who considered the promotion of the profitable labor-intensive crops as a threat to their control over the labor market (Hintermeister 1986, 11-12).

The Evolution of Export Cropping by Cuatro Pinos Farmers

The adoption of export vegetable production by small farmers in the Western Highlands is determined by long-term changes in economic variables, especially the increased demand for these crops in U.S. and European markets and the growing labor-land ratio on small farms. Both these factors increase the comparative advantage of labor-intensive crops in rural environments where there is increasing (seasonal) underemployment. International development assistance organizations played a catalytic role in the beginning for the rapid use of potential economic benefits from nontraditional export crop production in the Western Highlands. The interaction of four groups of actors finally led to the rapid expansion of export vegetable production.

1. External development assistance organizations were instrumental at two different levels. First, they provided the seed money (loans) to a private company, Alimentos Congelados S.A. (ALCOSA), to open up the export channel (Latin American Agribusiness Corporation S.A. [LAAD] and the U.S. Agency for International Development [AID]

played a role in this). Second, they stimulated the formation of the cooperative, implemented its programs, and assisted in securing access to the export channel through private exporters (Swiss Group, a Swiss nongovernmental organization).

2. An external private company (ALCOSA, a subsidiary of U.S.-based Hanover Brands, Inc.) provided the know-how and the export channel to the U.S. market, including such related infrastructure facilities as cold storage.

3. Guatemalan public institutions provided the know-how on agricultural technology (Instituto de Ciencias y Tecnologías Agrícolas [ICTA]) and farm-level credit (Banco Nacional de Desarrollo Agrícola [BANDESA]). INCAP developed vegetable-processing equipment.

4. Local farmers formed the Cuatro Pinos cooperative, which organizes export vegetable production and provides field-level extension, input supply, produce collection, selection, and storage. Lately the cooperative has organized its own exports independently from the ALCOSA outlet, both to the United States and to Europe.

The interaction of these players in the process of increased commercialization was quite different in the various phases of the process. The following calendar of events that led to the expansion of vegetable production for exports at Cuatro Pinos sheds light on this:

Year	Export Vegetables in Guatemala	Cuatro Pinos Cooperative
1970	LAAD founded (LAAD's Central American subsidiary mainly funded through USAID loans)	
1971	ALCOSA began operations in Guatemala with a LAAD loan (freezing fruits and vegetables)	
1975	ALCOSA purchased by Hanover Brands, Inc., and expanded with new loans from LAAD to export vegetables to United States (okra, broccoli, cauliflower, brussels sprouts)	
1976	Main production of vegetables for export by ALCOSA started on company lands leased by ALCOSA; small experiments with small farmers began	Earthquake in the Western Highlands; death toll about 30,000; Swiss Group comes to rebuild Santiago Sacatepéquez
1977	Buying stations set up to buy cauliflower from small farmers in highlands	Swiss Group's development programs—food aid, literacy courses, along with reconstruction work in villages; formation of groups that later formed the cooperative

1978	Rapid expansion of cauliflower program	Implementation of agricultural programs—maize improvement, traditional vegetables; contract with ALCOSA through Swiss Group for broccoli and cauliflower production in Santiago Sacatepéquez
1980	Production on ALCOSA's own farmland closed; all cold-weather vegetables now from small highland farmers (about 2,000 farmers in purchasing program, delivering to 17 stations); crisis of ALCOSA—contracts were signed for much more broccoli and cauliflower than plant's processing capacity; breakdown of field organization; suspension of purchases; losses to farmers	Construction of buildings for cold storage and packing at cooperative headquarters at Santiago Sacatepéquez; contractual arrangements with fresh snow pea exporters
1981	Expansion of processing capacities of ALCOSA; change in contractual arrangements with farmers	Rapid expansion of cauliflower, broccoli, and snow pea production and direct exports by cooperative to United States
1987	Five companies (Guatemalan) in addition to ALCOSA started frozen-vegetable business	Further expansion of cooperative; construction of own freezing, processing facilities; 20 percent of exports to Europe

Production technology, management, and on-field supervision requirements for export vegetables are well suited to small farms. The early experience of ALCOSA with crop production and procurement clearly indicates that the production of export vegetables (broccoli, cauliflower, snow peas) has rapidly decreasing returns to scale. The production initially started on land leased by ALCOSA where up to 400 people were directly employed by the company. Then ALCOSA contracted middle-sized farms of 20-40 hectares operated by agricultural entrepreneurs and, finally, shifted to small farmers. Although ALCOSA initially intended to depend on its own farming for raw material, it soon began to rely more on its outgrowers (Kusterer, Estrada, and Cuxil 1981, 13). The experience showed that nontraditional commercial farming entrepreneurs on the middle-sized farms were not a satisfactory source of supply.

The small farms' comparative advantage in vegetable production is due not only to the high labor intensity of the work tasks but also to careful on-field management and supervision requirements to meet quality standards that are better fulfilled by the small farmers experienced in traditional vegetable production. These production characteristics are important features for the sustainability of export vegetable production in the hands of small farmers. Along its development path, Cuatro Pinos has benefited from institutional support and soft loans for its investments but not from subsidies for on-farm production. The institutional support and know-how transfer was probably the most important ingredient for the growth of the cooperative.

By 1987, Cuatro Pinos had expanded to 1,150 members, compared with 177 members in 1979. The cooperative farmers were growing nearly 300 hectares of export vegetables in 1985. More than half of this area was devoted to snow peas. The area under these crops has quadrupled since 1980/81 (Table 6). At the cooperative headquarters, about 150 persons—more than half of them women—found employment in screening and packing work.

Sustainability of Export Crop Production by Small Farmers

Export vegetable production is frequently considered risky for small farmers. Various types of risks are distinguished: risk of crop failures (pests, weather), risk of price collapses, and risk of a breakdown of the marketing institutions (the domestic or external part of the channel or both).

The production risk at the farm level will be discussed later on the basis of farm survey data. The two "institutional" risks are addressed in the following sections.

Price Risk and Exchange-Rate Policy

Prices of export vegetables, and those of snow peas in particular, are extremely unstable compared with, say, staple food prices. Highest and lowest prices paid to Cuatro Pinos farmers in 1985 for snow peas of similar quality ranged from Q0.10 to Q2.00 with a median of about Q0.80 per pound (see Figure 2). These fluctuations reflect directly the actual price movements in the export markets (especially the spot markets in Miami, Los Angeles, and London). The fluctuations are the result of short-term supply-and-demand changes. Various regions enter the markets of these products at different times (for example, Mexico, California, and the Dominican Republic). Other types of fresh vegetables probably induce substitution effects on the demand side in various seasons, but little is known about these. However, it is important to note that the high degree of price instability of snow peas from week to week does not translate into a similar instability of returns from the crop. Harvesting of the crop starts 9 weeks after planting and extends over 10 to 12 weeks with three pickings of the crop per week. The grower is thus facing an average price over the whole harvesting period of a field. A farmer who, for example, planted his crop in the beginning of June 1985 and was harvesting in August, September, and October delivered his crop at prices ranging from Q0.10 to Q1.50 per pound with an average—depending on volume at the specific points in time—of about Q0.55 per pound. The price fluctuations listed

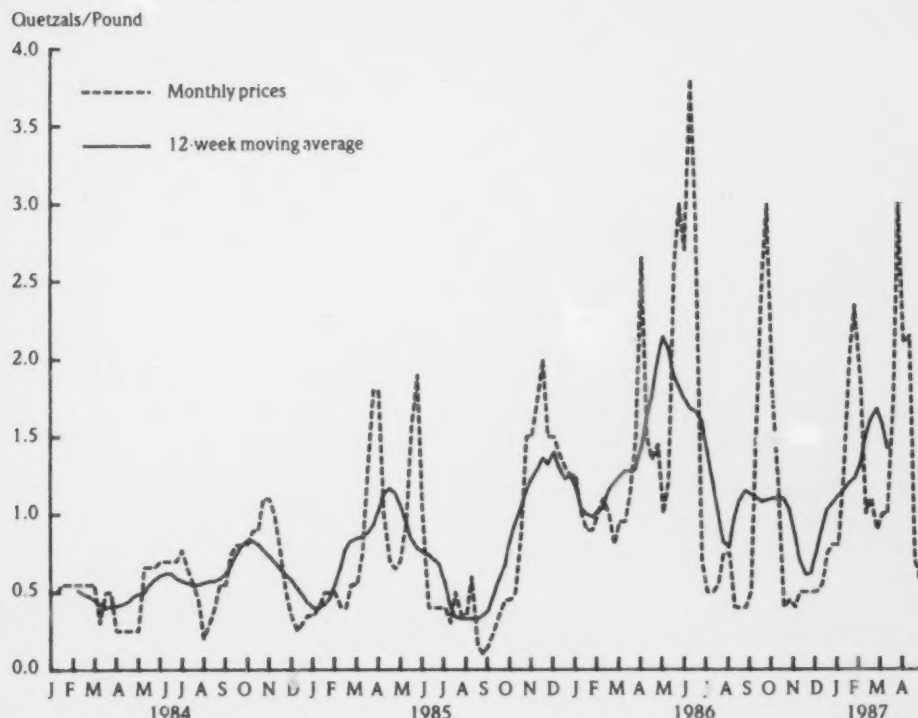
Table 6—Area under export vegetable crops marketed by the Cuatro Pinos cooperative, 1980-85

Crop	1980/81 ^a	1984/85 (hectares)	1985/86
Snow peas	6	90	170
Cauliflower	61	67	67
Broccoli	0	10	45
Parsley	0	2	7
Total	67	169	289

Source: Records of Cuatro Pinos cooperative.

^a Rough estimate.

Figure 2—Snow pea prices paid to farmers by cooperative, 1984-87



Source: Records of Cuatro Pinos cooperative.

in Figure 2 are thus smoothed out in 12-week moving averages with which they actually translate into gross revenues from the crop. Farmers also can—and actually do—grow the crops in phases on different plots at different points in a year, thus further reducing the price risk.

Such price variability is not necessarily a problem for farmers if it represents a seasonal pattern with predictable ups and downs in prices. For some time it was assumed that snow pea export prices were at a seasonal high during September-December and farmers were accordingly advised to plant for harvest at that time. In recent years, however, no clear seasonal price pattern has occurred, so farmers have been confronted with a high degree of uncertainty. Developments on the supply-and-demand side of the international market for snow peas—for example, increased demand from Western Europe and increased supply in various seasons from other producing regions such as the Dominican Republic, other Central American countries, and California—appear as important factors. Also, little is known about substitution effects of changes in prices of competing types of vegetables on the formation of prices for such luxury vegetables as snow peas. Predicting future crop prices, which is crucial for the sustainability of the export operation, is hardly possible with any acceptable margin of error. Demand in the rich countries of the North appears to be rising. However, as long as new technologies are not developed that would permit the cultivation of the crop with substantially lower labor input in comparable climatic zones, small farmers in the

Guatemalan highlands have a sustained comparative advantage due to the local labor supply situation. Deflated average prices for snow peas paid to cooperative farmers have shown neither a decreasing nor an increasing tendency since 1984: first-quarter averages (January-April in 1984 prices) were Q0.50 per pound in 1984, Q0.36 in 1985, Q0.76 in 1986, and Q0.61 in 1987. The variability of prices also shows no particular tendency in these years.

Comparative advantage of export vegetables at the farm level is directly affected by the exchange-rate policy, which determines changes in the price ratio between traded and nontraded agricultural products and inputs. Recently, exchange-rate policy changes in Guatemala have introduced an additional uncertainty element into the price environment. These policy changes are not predictable for farmers; thus the erratic exchange-rate policy discussed in Chapter 3 establishes one component of the price risk facing the farmer.

The overvalued exchange rate in the early 1980s and the multiple exchange-rate system in place in 1985/86 translate into a changing taxation of the export vegetables. In mid-1985, the exchange-rate system for vegetable exports required 50 percent of the sales value to be exchanged at the official rate (Q1.00 = US\$1.00) and permitted the other 50 percent to be exchanged at the parallel rate (about Q1.00 = US\$0.27). Even taking into account a common practice of underreporting the sales value, this exchange-rate policy resulted in an export tax of about 25 percent for snow peas (see Table 7). This tax favors production of domestically consumed traditional vegetables and, to some extent, the subsistence crops (maize and beans). It also suggests that returns to farm labor in the small enterprises in the Western Highlands are cut. The export tax for the labor-intensive new vegetables in the Western Highlands had adverse effects on employment and real income of the rural poor.

Table 7—Effect of exchange-rate policy on export vegetable producer price: an example from a snow pea sale by Guatemala to the United States, July 1985

Affected Item	Price and Tax Effects
(1) Actual "return price" of a shipment	US\$0.35/pound
(2) Declared "return price" of shipment (lowest price noted on market in reference period of shipping)	US\$0.25/pound
(3) 50 percent of declared "return price" at official exchange rate (Q1.00 = US\$1.00)	Q0.125/pound
(4) 50 percent of declared "return price" at parallel exchange rate (Q1.00 = US\$0.27)	Q0.463/pound
(5) Difference between actual and declared "return price" at parallel exchange rate (Q1.00 = US\$0.27)	Q0.407/pound
(6) Actual "return price" in domestic currency (position [3] + [4] + [5])	Q0.995/pound
(7) Tax due to official exchange rate applied to 50 percent of declared "return price" (in position [3])	Q0.338/pound
Tax in percentage of actual "return price" position (1) at parallel exchange rate	25.4 percent

Source: Information from traders in Guatemala.

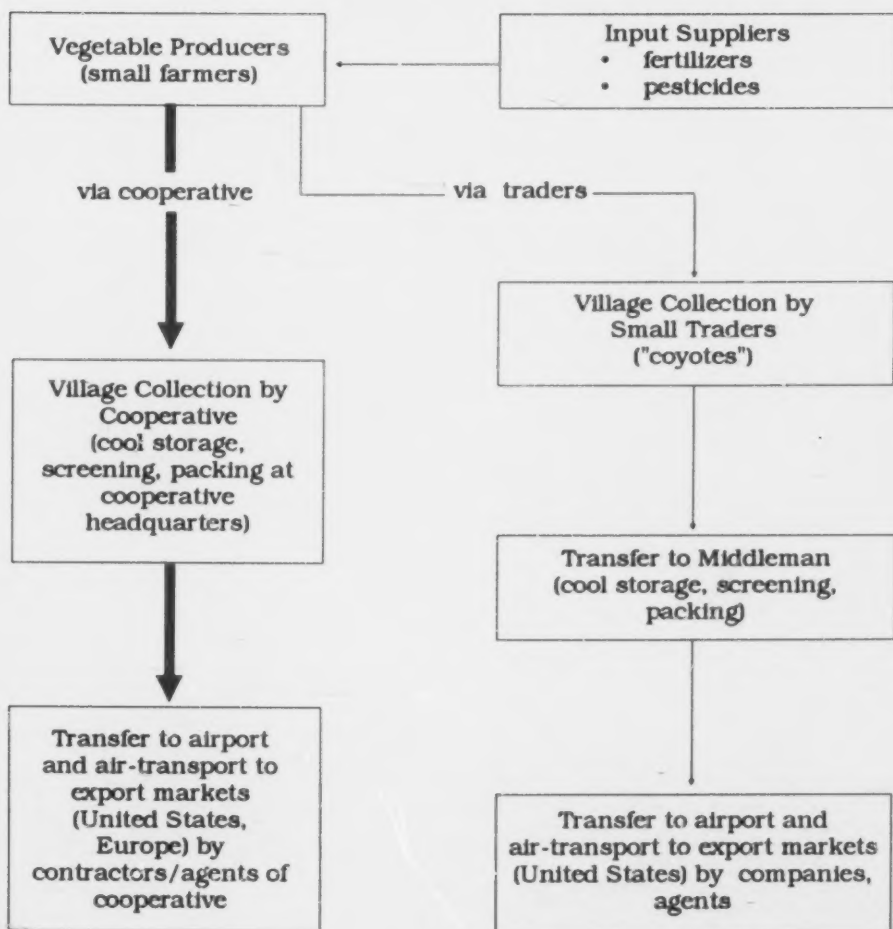
Note: "Return price" is the net price c.i.f. U.S. market (Miami) after transport and handling costs are deducted. It is "returned" to the exporting cooperative, which passes it on to farmers after deducting local marketing margins.

Risks in the Marketing Institutions

It is obvious that the sustainability of the export operation of a perishable commodity largely depends upon the proper functioning of the marketing channel of inputs and outputs (Figure 3). Input markets of fertilizers and pesticides appear to be well integrated in Guatemala. Domestic prices of inputs are largely determined by international price changes and by the exchange-rate policy.

The output marketing in the study area is largely via the Cuatro Pinos cooperative. The sustainability of this institution is crucial for the profitability of export crop production. Cooperatives in the Western Highlands have a mixed record of success. It has not been uncommon for cooperatives to collapse because of dishonest management practices or political reasons, especially during the period of violent conflicts in the

Figure 3—Marketing channels for fresh export vegetables from Guatemala



late 1970s and early 1980s. The survival and growth of Cuatro Pinos appears as a successful exception to the rule.

The technology required for the operation of the first phase of the export channel within the country is simple and does not require major external inputs or expertise. An important component of the marketing system is the flow of information from the export market to the cooperative and the growers. Increasingly developing its outreach, the cooperative has recently started shipping to European markets. This international flexibility further reduces the risk of dependence that occurred in the early stage of the export vegetable production when ALCOSA was the single buyer. In 1987 five companies besides ALCOSA processed frozen vegetables, and six other companies are operating the fresh vegetable export channel that now provides for a highly competitive market structure. Recently the cooperative has started to process dried vegetables (parsley) in storable form and has begun construction of its own freezing facility.

Also, farmers now have an alternative market outlet for export vegetables, in addition to the cooperative, via small traders who collect at the village level. The quantities acquired by these traders appear to be small in the study region. This competitive outlet reduces the risk to farmers that their access to export markets would break down in case of a collapse of the cooperative.

The marketing costs of fresh vegetables (for example, snow peas) are high. The consumer price in the United States was about five times the producer price paid in Guatemala in 1985 (Table 8). Apart from a 10 percent sales commission to the brokers

Table 8—Marketing costs of a fresh export vegetable (snow peas) from Guatemala to the United States, 1985

Item	Price per Pound	Prices and Marketing Costs in Percent of U.S. Consumer Price
Price paid to farmer	Q0.90 ^a (US\$0.57) ^b	19.0
Cost of marketing		
Local cost at cooperative		
Loss due to final selection	Q0.05	
Packing box	Q0.15	
Labor	Q0.03	
Coding	Q0.02	
Overhead or management	Q0.03	
Subtotal	Q0.28 (US\$0.08) ^c	2.7
Cost of exporting to the United States		
(Air) freight to Miami	US\$0.30	
Freight to sales place	US\$0.03	
Cooling	US\$0.02	
Customs	US\$0.03	
Commission for broker (10 percent of gross sale)	US\$0.10 (approximate)	
Subtotal	US\$0.48	16.0
Total marketing cost	US\$0.56	18.7
Total cost of produce c.i.f. Miami	US\$1.13	37.7
Marketing margin and profit in the United States	US\$1.87	62.3
Price to U.S. consumer	US\$3.00 ^d	100.0

Source: Records of Cuatro Pinos cooperative.

^a Approximate weighted average price for farmers in 1985; actually fluctuated between Q0.15 and Q2.00 per pound.

^b The weighted split exchange rate 50 percent at parallel (= Q3.65) and 50 percent official (= Q1.00) is used here.

^c The parallel exchange rate is applied here.

^d In 1985, this price varied between US\$2.00 and US\$4.00 per pound.

who arrange the sale in the U.S. market, the marketing costs (c.i.f. Miami) are not affected by the sales value. The marketing costs to Miami were about 18.7 percent of the consumer price, or roughly equal to the producer price. Any fluctuations in the U.S. market price are fully and immediately transmitted to the (Guatemalan) producer. Cutting marketing costs appears to be a desirable approach to benefiting producers and consumers, but in this particular case not much space appears available for cost-cutting measures.

Some interesting conclusions can be drawn from the assessment of "institutional risks" faced by the export crop producer. These risks can be reduced by opening up alternative marketing and processing lines at a level close to the farmers as well as by diversifying the export markets to avoid monopsonistic pressures. Options for diversification in production and processing and in export target markets within the group of export vegetables are substantial and have effectively been exploited as risk-reducing measures. The know-how for this—transferred via an institution such as a cooperative—may be at least as advantageous to farmers' income stability as any attempts to efficiently organize on-field production stability.

It is in the best interest of farmers that cooperatives and merchants not only coexist and compete at the produce-collection level but also operate independent export lines. This has finally been achieved in the area where Cuatro Pinos operates. However, such competitive structures cannot be expected to arise in the earliest phase of new export crop introduction. Monopsonistic patterns and related problems appear more likely, as in the early phase of export vegetable production (see Chapter 2). The export vegetable production of Cuatro Pinos started out as a contract activity with monopsonistic characteristics—a branch of a multinational corporation being the sole buyer in the country. Over a period of five years, the cooperative changed substantially as it began to operate independently and competitively in the regional and international markets, and as other private companies were set up. This development is basic to the reduction of the institutional risk involved in export crop production.

EFFECTS OF THE NEW EXPORT CROPS ON AGRICULTURAL PRODUCTION, INCOME, AND EMPLOYMENT

Adoption of Export Crops by Subsistence Farmers

Agriculture in the survey area was formerly dominated by production of maize and beans, with 10 percent of the land devoted to vegetables for the local market. Those farm households who are not members of the export crop cooperative and who live in the more remote sample villages still show this cropping pattern in 1985. In villages such as El Rejón, Pacul, and Pachalí, maize and beans cover 84-96 percent of the crop area of nonmember farms (Table 9).

The important relationship of access to infrastructure and degree of market integration is revealed by the case of Santa María Cauqué, which is located at the highway to Guatemala City. There, even nonmember households plant only 51 percent of their land with subsistence crops.

Cooperative members farm on average 0.94 hectare, while nonmembers farm 0.66 hectare. Comparisons of the two groups, therefore, must take the farm-size difference into account. Accordingly, most agriculture-related information is presented by farm-size classes in this chapter. It is interesting to note that with these holdings and the allocation of 52 percent of land to subsistence crops by members and 78 percent by nonmembers, households in both groups allocate on average about the same land area to subsistence crops (members, 0.49 hectare, versus nonmembers, 0.51 hectare).

Table 9—Farm size and cropping patterns of members and nonmembers of the Cuatro Pinos cooperative, 1985

Farm Size/Crops	San Matéo	El Rejón	Santa María Cauqué	Pacul	Pachalí	Santiago	Total Average
	(hectares)						
Average farm size							
Members	0.82	1.15	0.86	0.61	1.06	0.85	0.94
Nonmembers	0.64	0.95	0.83	0.80	0.58	0.54	0.66
	(percent of area)						
Maize, beans							
Members	48.8	62.6	41.3	45.3	42.4	57.7	51.8
Nonmembers	81.6	83.9	51.0	87.2	95.5	81.9	77.8
New cash crops							
Members	45.9	35.4	38.8	41.8	53.3	35.9	39.3
Nonmembers	4.0	8.0	22.1	3.3	1.5	7.3	8.9
Traditional cash crops							
Members	5.3	2.1	19.9	12.9	4.4	6.4	9.1
Nonmembers	14.5	8.1	26.9	9.5	3.0	10.9	12.8

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Parts may not add to totals because of rounding.

Export crop production is open to every farmer in the six communities where the Cuatro Pinos cooperative is active. Because merchants outside the cooperative have recently begun operation of another marketing channel for the new export crops, the option to grow export vegetables is not entirely tied to membership. However, with the exception of Santa María Cauqué, a centrally located village where many merchants base their operations, only a very small group of nonmember farmers grows the new crops. This means that becoming an export crop farmer is in most villages synonymous with becoming a cooperative member. This decision is a matter of free choice.⁸

The major decisions made in commercial and subsistence agriculture are decisions that are mostly made either exclusively by the male head of household or jointly by men and women but dominated by men. Nieves (1987) finds that the presence of the cooperative seems not to have altered this relation, at least not in the short term. In her case study on 21 households that are a subsample of the INCAP/IFPRI survey in 1985, Nieves found that the decision to become a member was, in all 21 cases, prompted by the male head of the household. In 16 of these cases, the male head asked the wife's opinion before taking any action. There are no legal or statutory barriers to female participation in the cooperative as members in their own right, yet very few women have membership status (5 out of more than 1,000 members in 1987). Nieves states that women in the study area will assume only public, visible roles that are culturally sanctioned. Applying to the local committee for membership would be an example of a public action traditionally not open to women. Cooperative membership is not a status that women feel they can attain, so they do not apply.

Membership in the cooperative is open to crop growers (but not necessarily to landowners) and small farmers by local standards (no member has more than 3 hectares). Members are obliged to participate in scheduled meetings of the organization and to pay a one-time membership fee of Q38. This enrollment fee is not negligible, as it roughly corresponds to 12 days' wages for a farm worker.

To test the determinants of adoption of export cropping, a probit model is estimated in which the dependent variable equals 1 if the household is an export crop grower, and zero otherwise:

$$Y_i^* = \beta' X_i + u_i, \quad (1)$$

where

$$Y = 1 \text{ if } Y_i^* > 0, \text{ otherwise}$$

$$Y = 0, \text{ and}$$

$$\text{Probability } (Y_i = 1) = \text{Probability } (u_i > \beta' X_i) = 1 - F(-\beta' X_i),$$

where F is the cumulative distribution function for u .⁹ The β' are maximum likelihood estimates. The bias toward a higher (nonrepresentative) members' share in the sample is taken into account in estimating the probit model. The true proportion of members versus nonmembers, known from the 1983 census information and the cooperative

⁸ For the first time, the cooperative was closed to new members in the fall of 1986, as the rapid expansion of members was considered unmanageable by the cooperative leadership. More members were admitted later, but the cooperative was closed to new members again in 1988.

⁹ For a description and discussion of the probit model, see, for example, Maddala 1983, 22-27.

records, is used to weigh the observations.¹⁰ The theoretical concept of the model application is the following: Income potentially earned off-farm determines the opportunity cost of working on-farm. In the long run, earning off-farm income versus increased on-farm work growing the labor-intensive export vegetables is a choice facing farm households. This choice is determined by the off-farm versus on-farm opportunity costs of family labor. Endowment of human capital and established off-farm employment opportunities determine these relationships for a specific household.

It is hypothesized that the choice to become an export crop grower was determined by the expected income increase, which can be assumed to be determined by the resource endowments of the farm (farm size, land quality) on the one hand, and the access to alternative, relatively secure off-farm employment on the other. It should be noted that only a secure (formal) off-farm income source enters here as an exogenous factor, since high substitution of daily wage earnings and occasional trading income versus on-farm work in the new export crop prevails, as is shown later.

It is further hypothesized that household labor force size and composition (women's share) may be a factor for adoption. A larger household labor force may enhance adoption of the labor-intensive crop, and a higher share of women's labor may induce a different balance of preferences and bargaining positions in the household. Since the decision is mainly that of the male head of household, his age, education level, and attitude toward traditional agriculture are other factors of hypothetical impact for the adoption decision.

The access of villages to infrastructure affects adoption of the new crops. This and the stepwise expansion of the cooperative into some of the villages suggest the inclusion of village-specific variables in the model. Based on these hypotheses, the adoption model is specified as follows:

$$\begin{aligned} \text{EXG} = f(\text{FSZHA}, \text{WLQ}, \text{FOFFY}, \text{LAB}, \text{RWOMLAB}, \\ \text{HHAGE}, \text{HHEDUC}, \text{HHTRAD}, \text{VILLAGE1}, \dots, 5), \end{aligned} \quad (2)$$

where

EXG	= export crop grower (= 1 if more than 10 percent of area in nontraditional export crops, else = 0),
FSZHA	= farm size (hectares),
WLQ	= land quality index (1 = best, . . . , 4 = worst),
FOFFY	= household income from formal off-farm employment (quetzals per year),
LAB	= total labor available in the household (that is, persons of working age), not disabled and not long-term absentees (in man equivalents),
RWOMLAB	= share of female labor in total labor of household,
HHAGE	= age of head of household (years),
HHEDUC	= household head's education (years of schooling),

¹⁰ The approach is described in Manski and McFadden 1982.

HHTRAD = household head's attitude toward maize production being "traditional" (= 1 if stated that most important reason for growing maize was for food and that second most important reason was that he grew maize to this extent because he always did so; else = 0), and

VILLAGE 1-5 = dummy variables for villages 1 . . . 5 = 1 each (else = 0); villages as listed in Table 1 from left to right.

The probit estimates are listed in Table 10 and can be used to derive linear probabilities β_{LP} , which can be approximated (see Amemiya 1981) by

Table 10—Probit estimate of export crop adoption

Independent Variable	Coefficient	t-Value	Approximate Probability of Joining Export Crop Production*	Mean Value of Variable	Standard Deviation
FSZHA	0.65970	5.105	0.2630000	0.689	0.644
WLQ	-0.19191	-1.109	...	2.120	0.456
FOFFY	-0.00021	-2.540	0.0000848	406.600	932.900
LAB	-0.08476	-1.544	...	3.780	2.360
RWOMLAB	-1.00440	-2.016	0.4020000	0.466	0.179
HHAGE	-0.00822	-0.833	...	38.700	12.400
HHEDUC	0.32280	0.692	...	2.930	1.730
HHTRAD	-0.36682	-2.263	-0.1470000	0.545	0.489
VILLAGE 1	-0.54760	-1.953	-0.2190000	0.119	0.324
VILLAGE 2	0.17560	0.692	...	0.113	0.317
VILLAGE 3	0.78250	3.632	0.3130000	0.186	0.389
VILLAGE 4	-0.23840	-0.811	...	0.076	0.265
VILLAGE 5	-0.16220	-0.558	...	0.095	0.287
INTERCEPT	0.72380	1.258	...	...	...

Notes: Dependent variable: Export crop grower (= 1, else = 0). Number of observations: 357. Chi-squared: 108.06.

- FSZHA = farm size (hectares),
 WLQ = land quality index (1 = best, . . . , 4 = worst),
 FOFFY = household income from formal off-farm employment (quetzals per year),
 LAB = total labor available in the household (that is, persons of working age) not disabled and not long-term absentees (in man equivalents),
 RWOMLAB = share of female labor in total labor of households,
 HHAGE = age of head of household (years),
 HHEDUC = household head's education (years of schooling),
 HHTRAD = household head's attitude toward maize production being "traditional" (= 1 if stated that most important reason for growing maize was for food and that second most important reason was that he grew maize to this extent because he always did so; else = 0), and
 VILLAGE 1-5 = dummy variables for villages 1 . . . 5 = 1 each (else = 0); villages as listed in Table 1 from left to right.

* The values in this column are the β_{LP} for the parameters estimated with a reasonable degree of statistical significance (above 95 percent level).

$$\hat{\beta}_{LP} = 0.4 \beta'. \quad (3)$$

The estimation results indicate that the decision of households to adopt the new export crops is not independent of household and farm characteristics:

1. Although all farms in the sample are small by almost any standard, an increase in size of farm significantly increases the probability of becoming an export cropper. Applying the above-mentioned conversion factor of 0.4 to the parameter estimate (FSZHA in Table 10) suggests that one additional hectare of farm size increases the probability of growing export vegetables by 26 percent. The adoption-farm size relationship is complex. This finding of increased probability of adoption *within* the small-farm sector with rising farm size is not contradictory to the earlier finding that the new export crops moved in a trial-and-error path from production on large-scale exporter enterprises to contract growing on medium-sized farms of 20-30 hectares to the small-farm sector. As the probability of adopting *within* the small-farm sector *increases* with farm size up to a certain level, economies of scale are apparently not linear at the tail end. It is found, however, that those smallest farms that did adopt actually allocated a higher share of their land to the new crop. Adoption and extent of adoption are thus not synonymous.

2. Increased income from formal off-farm employment—that is, relatively secure income from sources other than day labor—decreases the likelihood that households will grow export crops. The estimation result suggests that if this type of relatively secure income increases by Q500 (which is approximately the difference between the mean and standard deviation of FOFY), the probability of joining the scheme decreases by 4 percent.

3. An increased share of women's labor in total labor significantly reduces the probability of growing export vegetables (RWOMLAB) after controlling for total labor force of the household (LAB). As noted earlier, adoption of the new crop is primarily a male decision, and the model results suggest that households with a female-dominated labor force stay away from the new crop.

4. Traditional motivation to grow maize (HHTRAD) significantly decreases the probability of becoming an export crop grower.

5. For households located in a remote village that has recently been included in the scheme (village 1, San Matéo), the probability of becoming a member appears lower, while it is significantly higher in village 3 (Santa María Cauqué), which is located at the highway.

The statistically nonsignificant results in the probit model are also interesting to note:

1. Differences in land quality of the farm (WLQ) have not significantly affected the choice of becoming an export crop farmer.

2. Availability of household labor does not significantly affect the choice of becoming an export crop grower. The market for hired labor is highly integrated in the region, which suggests this model outcome.

3. The age and level of education of household head, which were assumed in order to indicate human capital endowment of the household, do not significantly affect the adoption probability.

In summary, it may be concluded from these results that the less traditional farmers on the somewhat larger (small) farms and those who do not have access to relatively secure (formal) off-farm employment were most likely to adopt the export crops.¹¹

¹¹ The probit model of the same specification was also estimated for the dependent variable defined as membership/nonmembership in the cooperative (= 1,0). While the results for the farm size and off-farm income variables were similar, the other variables were not statistically significant in that model.

That comparatively larger farms were joining the cooperative becomes clear from the distribution by farm-size class among the member and nonmember groups. Table 11 reveals a tendency often observed in patterns of adoption of "green revolution" technologies in peasant agriculture; more of the early adopters have somewhat larger farms (more than 1 hectare) than adopters who join later.

Profitability and Risks of New Export Crops and Subsistence Crops

For those farmers willing to adopt new export crops, the returns of those crops to factors of production (that is, land and labor) is central. In addition to the average profitability, the stability of returns from these crops is an important factor, as risk may be an issue of concern. Gross margins are used as measures of profitability. The gross margins calculated are based upon the 1985 survey covering the 1984/85 cropping season as expressed in the cropping calendar (Figure 4). Gross margins are the value of output minus the direct costs. Rent for land is not included. To assess the competitiveness of various crops at the farm level, gross margins are expressed per unit of land and per family-labor day.

Since snow peas stand out as the main new-crop in the following comparisons, its agronomic characteristics will be mentioned here. The peas are sown in rows. When they are about 20 centimeters high, the plants are tied to ropes that are stretched between sticks along the rows of plants. The plants grow up to about 1-1.3 meters on the continuously added ropes. The main work tasks are weeding, spraying for pest control, and picking the peas. Picking starts after an 8-week growing period and extends over 10-12 weeks. The crop is thus on the field from 18 to 20 weeks. Snow peas are sprayed two times per week over the growing period. The cost of recommended spraying in 1984/85 was Q596 per hectare. Because the devaluation of the quetzal on the parallel market sharply increased this cost (see Chapter 4), the 1986 spraying bill was 310 percent of the 1984/85 bill. The wage bill for snow peas is also considerably higher than for any of the competing crops. The related employment issues will be addressed later.

Being a legume (a variety of *p. sativum*), the snow pea enriches the nitrogen content of the soil, which benefits crops that follow in the rotation.

Snow peas yield a gross margin per unit of land 15 times higher than that of the principal subsistence crop, maize, on cooperative member farms (Table 12). Per unit of family labor, the gross margin of snow peas is about twice the margin reported for

Table 11—Farm-size distribution of cooperative members and nonmembers

Farm Size (hectares)	Nonmembers (percent)	Length of Membership		
		2 Years or Less	3-4 Years	5 Years or More
			(percent)	
Less than 0.25	25.8	5.0	6.1	2.8
0.25-0.50	36.0	20.0	24.5	20.8
0.50-1.00	21.3	47.5	40.8	41.7
1.00 or more	16.9	27.5	28.6	34.7
Total	100.0	100.0	100.0	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Figure 4—Cropping calendar of subsistence crops, traditional vegetables, and export vegetables in the Western Highlands, 1984/85

Crop	1984												1985						
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
Maize																			
Beans																			
Traditional vegetables ^a																			
Broccoli, cauliflower ^b																			
Snow peas ^c																			

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: The double lines show the main periods of planting, growing, and harvesting; the single lines show extended periods during which a minority of farmers engage in these activities.

^a Cabbage, carrots, radishes, and others.

^b Main planting season, May-August; main harvest season, June-September.

^c Main growing period, August-April; main harvest period, October-June.

maize, as snow peas absorb 7 times more family labor per hectare, or 5 times more total labor input in terms of days, than maize. Traditional vegetables are roughly as profitable as broccoli and cauliflower per unit of family labor. Beans are between maize and the above vegetables. The per hectare input costs of snow peas are about 13 times as high as those of maize. These high input costs of snow peas stem from high use of pesticides and from the costs of special production inputs (sticks to bind the plants and ropes to tie the climbing snow pea plants to the sticks).

Cooperative members finance the considerable input costs partly through agricultural credit. Forty-two percent of members had received credit during the previous year. On average the sum borrowed amounted to Q480, which covered the variable input cost for 0.3 hectare of snow peas. Only 3 percent of the nonmembers reported having had access to credit during 1984/85. It is interesting to note that those farmers who grow the new export vegetables under the cooperative scheme have higher returns and lower unit costs of production in the maize crop than other farmers (columns 1 and 2 of Table 12). The input cost and wage bill are higher for members, yet their output per unit of land is further increased, thus leading to this outcome. The relationship of this pattern to the export vegetables is analyzed in detail below.

The ranking of crops by their profitability shows a similar pattern if the sample is disaggregated by farm-size class (Table 13). There is a tendency for maize gross margins per hectare to decrease with increasing farm size, both for export crop producers and other farms, but returns to family labor do not differ a great deal between farm-size classes. Constant returns to family labor and decreased returns to land with increased farm size indicate that larger farms operate at higher cost levels per unit of land or at lower yield levels or both. No general tendency is visible from the tabulations of gross margins of the new export vegetables per unit of land and labor. The apparently negative scale effects for these crops, discussed above in the context of ALCOSA's experience (Chapter 4), may become effective only outside the range of small farm sizes observed in the sample.

Table 12—Cost of production and gross margins of export vegetables and subsistence crops, 1984/85

Item	Non-member Farms, Maize	Cooperative Member Farms				
		Traditional Crops			New Export Crops	
		Maize	Beans ^a	Traditional Vegetables	Broccoli, Cauliflower	Snow Peas
(quetzals/hectare, mean values of sample)						
Seeds, plants	0.20	0.21	26.55	106.30	85.76	54.87
Fertilizer	100.12	105.60	85.28	158.61	243.82	216.16
Other inputs	13.66	14.85	55.10	167.95	103.88	1,296.13
Total inputs	113.98	120.66	166.93	432.86	433.46	1,567.16
Wages paid	96.22	167.71	133.69	306.06	283.58	552.71
Value of output	353.75	457.80	681.00	1,804.53	1,339.17	4,416.20
Gross margin per hectare ^b	120.43	143.87	362.79	1,065.61	593.37	2,204.15
(days/hectare, mean values of sample)						
Days of family labor per hectare ^c	63	54	121	299	168	400
Days of total labor per hectare ^d	101	119	172	416	277	613
(quetzals/day, mean values of sample)						
Gross margin per day of family labor	1.91	2.66	2.99	3.47	3.53	5.51

Source: Computed from data from Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: The mean values are based on 173 observations on nonmember farms and 160 observations on member farms.

^a Beans in sole stand.

^b To compute the gross margin from value of output, wages, and total inputs, interest on the sum of purchased inputs and on the part of the wage bill for nonharvest labor is deducted. The interest rate used is 15 percent adjusted to the duration of the crop's growing period.

^c Men's, women's, and children's labor days are weighted by 1.0, 1.0, and 0.6, respectively.

^d This includes hired labor.

Cooperative members on average have higher returns than nonmembers to both land and family labor for the three comparable crops (maize, beans, and traditional vegetables; see totals in Table 13). In general, this pattern is also revealed within the farm-size classes.¹² Thus it appears that the more efficient farmers joined the export crop scheme, as there is no indication of basic differences in land-resource quality between the two groups. Yet, joining the cooperative may also have improved farmers' access to yield-improving technologies—for example, inputs and information. These aspects will be evaluated in more detail below. At this point it is worthwhile to note that export crop producers achieve higher returns to land and family labor from subsistence crops (maize and beans) than do other farmers, although the export crop farmers devote more resources to the new export vegetables.

The gross margin (net return) per day of family labor indicates the level of opportunity cost of family labor in agriculture. The gross margins per family labor day fall in the range of local wage rates, which were Q2.00-2.50 in 1984 and Q3.00-3.50 in 1985

¹² It should be noted that many different crops are aggregated into the group of traditional vegetables. The related gross margin figures vary considerably between farms due to this aggregation.

Table 13—Gross margins of export and traditional crops per hectare and per person-day of family labor, by farm size, 1984/85

Farm Size/Unit	Export Crop Producers					Traditional Crop Producers		
	Maize	Beans	Traditional Vegetables	Broccoli, Cauliflower	Snow Peas	Maize	Beans	Traditional Vegetables
(hectares)	(quetzals)							
Less than 0.25								
Per hectare	(188.00)	...	(407.00)	...	(2,198.00)	127.00	181.00	852.00
Per day ^a	(2.61)	...	(1.00)	...	(3.74)	1.98	3.18	1.64
0.25–0.50								
Per hectare	175.00	(254.00)	(2,654.00)	(365.00)	2,791.00	149.00	191.00	609.00
Per day ^a	3.13	(7.70)	(7.97)	(2.81)	6.10	2.10	3.19	2.14
0.50–1.00								
Per hectare	146.00	187.00	375.00	645.00	1,785.00	85.00	(25.00)	397.00
Per day ^a	2.43	2.25	1.24	3.41	4.52	1.42	(0.32)	1.15
1.00 or more								
Per hectare	117.00	648.00	860.00	624.00	2,398.00	84.00	83.00	935.00
Per day ^a	2.72	5.36	3.54	4.22	6.97	1.83	3.19	4.16
Total								
Per hectare	144.00	363.00	1,066.00	593.00	2,204.00	120.00	130.00	659.00
Per day ^a	2.66	2.99	3.47	3.53	5.51	1.91	1.76	1.96

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Values computed from 10 observations or fewer are in parentheses. The export crop producers are members of the cooperative; the traditional crop producers are not members.

^a Children's labor days are weighted with a factor of 0.6; men's and women's labor days are weighted with 1.0 each.

for a man's person-day in the field. Women's wage rates are reported to range from Q0.50 to Q1.00 lower than men's. Returns to family labor on export crop farms exceed these male and female wage rates by a substantial margin. As a result, the labor supply into the local labor market from these farm households has substantially decreased.

Inseparable from the assessment of profitability of new export crops versus traditional crops is their comparative risk. There is a great deal of uncertainty about the new crops' output and input price fluctuations. A long-term longitudinal study would be required to properly address the issue. Moreover, it should be reiterated that new export crops particularly impinge on the off-farm labor supply of small farm households in the Western Highlands. The comparison of risks in reallocating household labor away from the uncertain off-farm labor market into their own uncertain new crop enterprise is as important as the between-crop comparisons, which is the focus of most literature on farm production risk. While this study is not designed to assess this aspect, it should be kept in mind that the between-crop comparisons are of limited relevance for an agricultural system that is as closely integrated into the nonagricultural labor market as is the case with farmers in the Guatemalan highlands.¹³

A first indication of differences in degrees of price risk for crops is given by the variance of prices within a cropping year across the survey area. Clearly, average prices received by farmers for the new export crops vary much more than the maize price but not more than the price of beans and traditional vegetables grown for the local

¹³ Increasing labor market participation in case of crop loss is a common risk-adjustment strategy of small farmers in Central America. In a survey in El Salvador, it was found to be the most frequently used strategy. See Walker and Jodha 1985, 17-34.

markets. As shown below, the coefficients of variation of snow pea, broccoli, and cauliflower prices in 1985 tended to be even lower than those for beans and selected traditional vegetables.

<u>Crop</u>	<u>Coefficient of Variation</u>
Maize	0.23
Beans	0.83
Traditional vegetables	
Beets	0.77
Radishes	2.27
Lettuce	0.63
Spinach	1.00
New export crop	
Snow peas	0.58
Cauliflower	0.52
Broccoli	0.24

It should be noted, however, that the intrayear price differences of beans and traditional vegetables may be of a seasonal nature that could be predicted by farmers with a certain probability. Thus the level of uncertainty related to price variability of traditional crops may be less than, say, for snow pea prices, which do not follow a clear seasonal pattern (see discussion in Chapter 4).

A second indication of the risk of new export crops versus traditional crops is given by a comparison of the variation of their respective gross margins per hectare. We find that gross margins of the new export vegetables tend to be less variable across the sample than those of traditional crops.

Relative variability crop-by-crop does matter, but levels of potential losses as a proportion of the asset base (land) are also important for the determination of household risk. Given the high input levels for new export crops, the potential loss from crop failure, output-price depression, or input-price increases may constitute a much higher probability of substantial income loss. To assess this aspect, the frequencies and levels of losses from traditional crops and new export crops are evaluated. Losses are represented in this assessment by negative gross margins, that is, net returns to land and unpaid family labor were negative, as variable costs exceeded the gross value of production. A combination of factors may lead to this outcome; for example, unfavorable input-output ratios, high input or low producer prices, or both. From this comparison, it becomes evident that farmers produced the new export crops at a loss as frequently as the traditional crops in 1985.¹⁴ However, to take the two extreme cases—maize and snow peas—in 24.5 percent of the sample fields, gross returns of maize do not cover the variable costs and, similarly, in 25.1 percent of the fields, gross returns of snow peas do not cover these costs. The absolute loss per unit of land is about 10 times as much in the case of snow peas as it is for maize (Q130 versus Q1,309 per

¹⁴ It should be noted that the percentage levels of negative gross margins might be somewhat overstated due to the usual noisiness of such recall surveys that leads to extended tails of the distribution function of variables. For this analysis, only the *relative* comparison across crops is relevant, and that should not be affected too much by this problem.

hectare). Clearly, this new export vegetable appears quite risky if viewed in isolation on the farm, but most farmers tend to minimize loss by devoting only a fraction of their land to the new crop.

Losses and gains from crops within the farm enterprise may compensate for each other. A comparison between cooperative members and nonmembers shows that the percentage of farms that reported an overall income loss was similar in both groups in 1984/85 (17.8 percent of members and 16.8 percent of nonmembers). The income losses in percentage of total expenditures averaged 7.7 percent in the member households and 5.7 percent in the nonmember households. This suggests that overall income risk does not appear significantly greater among members than nonmembers.

Effects of New Export Crops on Land Use and Land Market

Despite the small absolute differences in farm size, cropping patterns change substantially by farm size. It is particularly interesting to note the case of maize. With increasing farm size, the share of maize in land use increases in member farms but decreases in nonmember farms (Table 14). Snow peas—the principal new export crop—have a relatively higher share in smaller farm-size classes of cooperative members. While the probit model (Table 10) indicated that the choice to become an export cropper is biased toward the somewhat larger farms within the small-farm sector, the relative scale at which new export crops are adopted (once the decision to grow them has been made) appears larger in the smaller farms (or at least the same as in the bigger farms if snow peas and broccoli-cauliflower are viewed together). It is noteworthy that some nonmembers of the cooperative also grow the new crops. They are mainly located in one village close to the Inter-American Highway, where traders have started to pick up export vegetables.

An effort is made in the survey to assess differences in land quality between member and nonmember farms. Farmers were asked to evaluate each of their fields according to a scale of 1 to 4 ("very good," "good," "not so good," "poor") in comparison with

Table 14—Cropping patterns of cooperative members and nonmembers, by farm size, 1985

Farm Size	Maize	Beans	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables	Other
(hectares)	(percent of cropland)					
Members						
Less than 0.25	35.3	3.2	44.9	...	14.5	2.1
0.25–0.50	41.4	5.0	28.9	8.4	13.5	2.6
0.50–1.00	45.3	6.6	27.7	13.0	5.2	2.3
1.00 or more	48.4	5.7	25.6	12.5	5.3	2.5
Total	46.7	5.2	28.0	11.1	6.7	2.4
Nonmembers						
Less than 0.25	67.7	13.1	5.8	...	12.4	0.5
0.25–0.50	60.0	19.0	4.8	1.8	11.0	3.4
0.50–1.00	60.7	14.2	7.0	4.1	12.7	1.3
1.00 or more	54.0	12.8	15.8	7.0	9.1	1.3
Total	66.1	11.7	6.3	2.5	11.4	1.9

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

the land quality in their community. A variable derived from this subjective evaluation, included in the probit model in Chapter 4, was insignificant for adoption. Although the distribution pattern of the surveyed fields by members and nonmembers (Table 15) underscores that there are no indications of substantial difference in land quality between member and nonmember farms, there is a clear indication that cooperative members grow the new export crops on their better pieces of land. The members planted new export crops on 69.2 percent of their land identified as "very good," but on only 31.6 percent of the land classified as "not so good."

The much higher returns of new export vegetables per unit of land, compared with traditional local vegetables or subsistence food crops, can be expected to impinge on the local land market. Demand for the quality land should increase, thus increasing land prices in the prevailing situation of extreme land scarcity. Given the shortage of cash and limitations of collateral for borrowing substantial amounts of money, the increased demand for land is hypothesized to be largely realized on the land-rental market rather than through land purchases. Yet, as the survey indicates, both the land-rental market and the land-purchase market appear to be stimulated by increased land demand from export crop growers. Cooperative members use a significant share of their rented land (20 percent) for the new cash crops (Table 16). Also, members pay higher rents per hectare of land used for new cash crops than for land rented and used for subsistence crops (rents per hectare are 42 percent higher for export vegetable fields). This may be due to the better land quality demanded for these crops.

Table 15—Relative quality of land of cooperative members and nonmembers and of land used for the new export crops

Land Quality	Share of Parcels in Each Quality Group		Share of Parcels Used by Members for New Export Crops
	Members	Nonmembers	
	(percent)		
Very good	10.2	7.2	69.2
Good	74.3	74.4	55.9
Not so good	14.9	17.6	31.6
Poor	0.6	0.8	0.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Table 16—Landownership of parcels and use for new cash crops

Land Status	Cooperative Members		Nonmembers Share of All Parcels
	Share of All Parcels	Share of Parcels Used for New Cash Crops	
	(percent)		
Owned	76	73	77
Rented	17	20	15
Other ^a	7	7	8

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Other forms of land acquisition, that is, temporary reallocations of land among members of a family.

Cooperative members expanded their own total land area during 1984 and 1985. Nonmembers had only a small increase. The reported net increase of members' land is 12.2 percent of the 1985 area compared with a 1.4 percent increase in the nonmember group. Land purchases are more frequent among the members, as 23 percent of the members reported a land purchase during the two years compared with only 8 percent for nonmember households. Usually very small amounts of land are purchased. Cooperative members were paying much higher prices for new land than nonmembers (Q6,272 versus Q3,150 per hectare). As in the case of rented land this may be due to the members' demand for more quality land for expansion of new export crop production versus the nonmembers' acquisition of more land for maize and beans.

Two conclusions are highlighted from this assessment of the effects of new export vegetables on the land market. First, the effective demand for land is increased as export crop producers expand their landholdings through rentals as well as land purchases. This expansion tends to further widen the existing gap in land size within the small-farm sector between export crop producers and other farmers. In the long run, it should be expected that a concentration of quality land will evolve in the sector of new export crop farmers, although currently there is no evidence of such a distinction.

Second, increased land values may be realized by land sales, renting out land, or making use of the increased collateral value of owned land on the capital market. Landowners in the area thus benefit from the increased land values induced by export crop production, regardless of whether they actually are export crop producers. Adversely affected through this effect are farm households that rent in land, especially if they have not taken up export cropping. Maintaining subsistence food levels from own production on rented land has become more expensive. The pressure to either give up rented land or join the export cropping scheme is increased due to the increased cost of land rental.

Effects of New Export Crops on Labor Demand and Employment

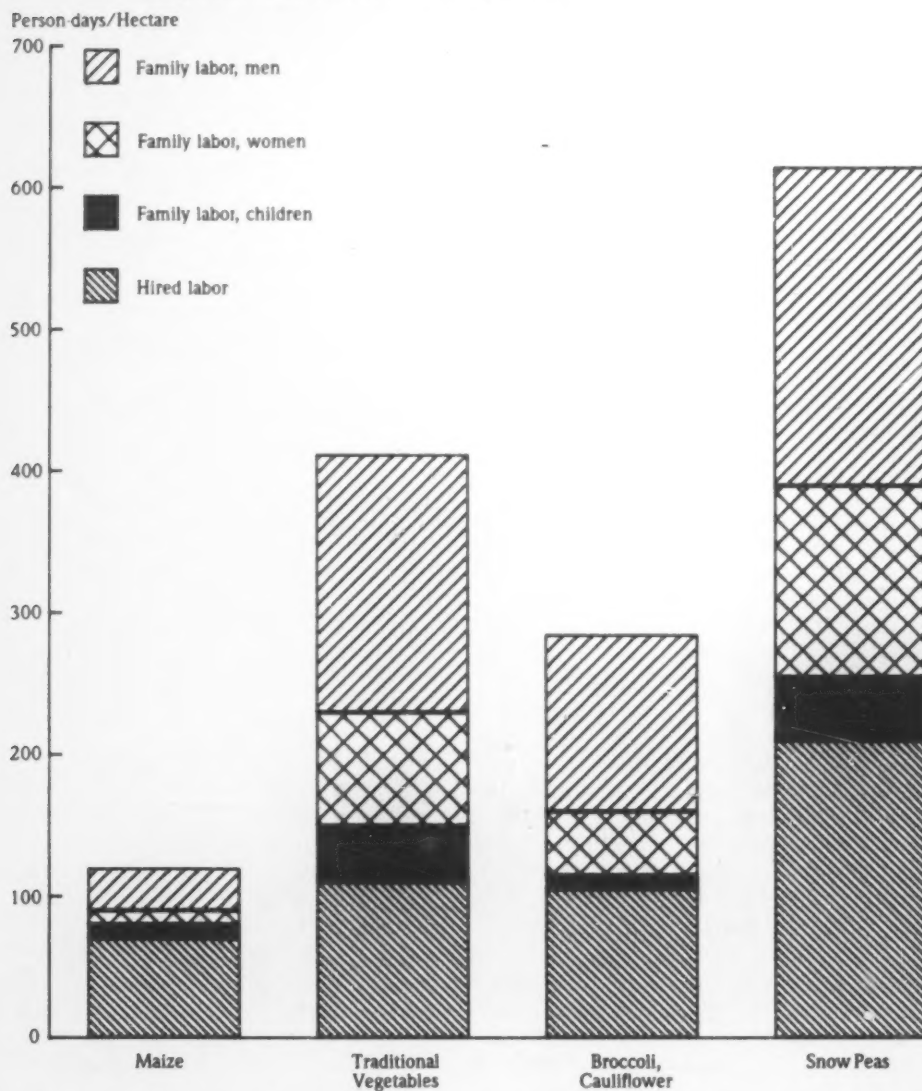
The new export crops create employment directly on the field and through forward and backward linkages, and indirectly through multiplier effects of the related income and employment. Their backward linkages are substantial. These crops have much higher input demands—not only for pesticides and fertilizers, which are not very labor intensive—but also, in the case of snow peas, for the locally manufactured sticks and ropes required for tying plants. Also, forward linkages are significant for employment, as the operation of the first stage of marketing is quite labor-intensive (selection, screening, and packing of produce). There are indirect employment effects from potentially higher income spent on goods and services with a high employment content. The following discussion focuses on the direct employment effects.

The new cash crops require much more labor input per unit of land than maize, the main subsistence crop (Figure 5). Snow peas also require more labor than traditional vegetables. Hired labor input is substantial, not only in the cash crops but also in subsistence maize, as more than half of the total labor input in maize is hired.

Most labor in all crops is provided by men, but this varies by crop type and by farm-size class. Women are responsible for 9 percent of family labor in maize, 25 percent in traditional vegetables, and 31 percent in snow peas (Table 17).

Family labor input per hectare decreases with increasing farm size for maize and traditional vegetables as well as for new export crops (Table 18). This family labor input is combined with increased hired labor inputs. Even in the smallest farm-size

Figure 5—Labor inputs for traditional crops and new export vegetables on cooperative members' farms, 1985



Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Table 17—Shares of men, women, and children in total family labor of cooperative members, by crop

Labor	Maize	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables
	(percent of family labor)			
Men	85	59	70	61
Women	9	31	20	25
Children	6	10	10	14

Source: Computed from Table 18.

classes substantial wage bills per hectare are incurred from new cash crop production (Table 19).

Division of family labor among men, women, and children in the production of new export crops is not uniform across farm size. As shown below, men's share of total family labor remains quite stable across farm-size classes, while women's share declines and children's share increases.

Farm Size (hectares)	Men	Women	Children
	(percent of family labor)		
Less than 0.25	59	39	2
0.25–0.50	59	33	7
0.50–1.00	58	32	10
1.00 or more	58	26	15

With increasing farm size women's labor is relatively replaced by hired labor and child labor. This is not true for men's labor. The high substitution between women's labor and hired labor is a phenomenon observed widely across countries of the Third World (see, for instance, Boserup 1970, 30). It is probably related to the increasing opportunity cost of women's labor in the field when the combined household and farm enterprise expands. Returns to female household labor, including such activities as meal preparation for hired labor, increase and lead to higher degrees of specialization within the farm-household. This still means that absolute levels of family labor input by both men and women may increase with increasing farm size.

The pattern of hired labor use changes with the introduction of new export vegetables. Cooperative members demand more hired labor for the subsistence crop (maize) on a per hectare basis than do nonmembers in the same farm-size class (Table 19). This demand for hired labor is a result of the inability of family labor to meet the increased demand of producing cash crops. The production level of traditional crops is maintained to a certain extent by hiring outside labor for their cultivation.

The direct employment effects of new export crops on farms can be approximately accounted for by tracing the partial effects due to (1) switching land between traditional crops and new crops, (2) the change in labor input per unit of land, and (3) related substitutions between types of labor input, that is, family labor (men, women, children) and hired labor. These changes of allocation of crops and labor differ by farm size. In a given farm-size class (i) the net employment effect (E) is then

Table 18—Average family labor used per hectare by cooperative members and nonmembers, by farm size and crop

Family Labor	Farm Size	Members				Nonmembers	
		Maize	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables	Maize	Traditional Vegetables
	(hectares)				(person-days/hectare)		
Men	Less than 0.25	64	350	...	271	53	399
Women		8	228	...	141	7	68
Children*		...	10	...	0	4	53
Total		72	588	...	412	64	520
Men	0.25–0.50	49	272	105	176	60	180
Women		6	152	25	100	6	69
Children*		1	34	0	57	5	36
Total		56	458	130	333	71	285
Men	0.50–1.00	50	231	133	181	52	249
Women		6	126	41	61	7	90
Children*		4	39	15	61	1	6
Total		60	396	189	303	60	345
Men	1.00 or more	37	200	104	167	42	169
Women		2	91	25	64	2	44
Children*		5	53	26	12	2	12
Total		44	344	155	243	46	225
Men	All sizes	45	234	117	181	54	239
Women		5	125	33	76	6	69
Children*		3	41	18	42	3	28
Total		53	400	168	299	63	336

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

* Children's labor input is weighted with 0.6.

$$E_i = \sum_j [\sum_s (a_{ijs}^* \cdot L_{ij}^* - a_{ijs} \cdot L_{ij}) + w_{ij}^* \cdot L_{ij}^* - w_{ij} \cdot L_{ij}], \quad (4)$$

where

a_{ijs}^*, a_{ijs} = per hectare labor input (days) of family labor types s ($s = 1, \dots, 3$) in crop j ($j = 1, \dots, 6$) and farm-size class i ($i = 1, \dots, 4$) with (a^*) and without (a) the new export crops in the production program,

w_{ij}^*, w_{ij} = per hectare wage labor input (days) with (w^*) and without (w) the new export crops, and

L_{ij}^*, L_{ij} = land used (hectares) for each crop (j) in farm-size class (i) with (L^*) and without (L) the new export crops.

While the situation of new export crops is represented by the situation of land and labor allocation in the cooperative member farms, the "without" situation is represented by nonmember farms of the respective farm-size class that do not grow the new crops. Participation in the scheme was found to be influenced by farm size and secure off-farm employment (see the probit model above). While the farm-size effect is accounted for by the disaggregation into farm-size classes, the effect of off-farm employment is not. One might suspect that cooperative member farmers were growing some of the more labor-intensive traditional vegetables before they switched to export vegetables. This hypothesis, which can be assessed by the small number of farmers who became members between the two surveys, is not supported. Therefore, the cross-sectional evaluation

Table 19—Wages paid for hired farm labor by cooperative members and nonmembers, by farm size and crop

Farm Size (hectares)	Members				Nonmembers	
	Maize	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables	Maize	Traditional Vegetables
	(quetzals/hectare)					
Less than 0.25	135	158	...	...	95	141
0.25–0.50	159	469	149	128	65	73
0.50–1.00	143	618	249	350	122	438
1.00 or more	209	570	368	340	136	358
Average	168	553	284	306	96	165

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

of the employment effects appears reasonable. Table 20 presents the results of the above computations. The main findings are as follows:

1. Labor input in agriculture increases in the export crop-producing farms by 45 percent (81 days per crop season).

2. This increase is equally shared by family labor and hired labor.

3. The increased labor demand results primarily from snow pea production. On average, labor is cut back in maize by 7 days (13 percent), beans by 6 days (43 percent), and traditional vegetables by 12 days (29 percent), but total hired labor input into maize increases somewhat.

4. In the smallest farm-size class virtually all the net increase in labor input comes from family labor. Total labor input on these farms of less than 0.25 hectare more than doubles.

5. With increased farm size more hired labor is covering the increased work load, but in all four farm-size classes family labor input increases by a roughly similar absolute amount.

6. A substantial share of the increased family labor is from women—44 percent in the two smallest farm-size classes and 32 percent in the largest farm-size class.

The farm-level data can be used to extrapolate the employment effects to the six communities where the cooperative is operating. For 1985, the increased labor demand in crop production corresponds to about 15 percent of agricultural employment. When added to the employment in input supply (special input shops in the villages and special production inputs for snow peas) and output marketing (cooperative staff), it yields an increase in agricultural employment of 21 percent.

Clearly, the employment effects are significant and impinge on off-farm employment and interregional migration in the location. Among export crop producers an average of 0.72 persons per household work away, compared with 0.92 family members among the other sample farmers. Also, nonmembers of the cooperative spend more time away over the year (4.2 versus 2.3 months on average).

The increased demand for hired labor in the region spreads the employment effect. Much of the hired labor comes from neighboring communities where export crop production has not been introduced.

Effects of New Export Crops on Staple Food Production

The evaluation above shows that new export vegetables yield higher returns per unit of land and labor than subsistence crops. Yet cooperative members still plant on

Table 20—Direct employment effects of the new export vegetables, by farm size

Farm Size/ Labor	Change in Labor Input Due to Shifts in Crop Area and Reallocation of Labor						Total
	Maize	Beans	Traditional Vegetables	Other Crops ^a	Broccoli, Cauliflower	Snow Peas	
(hectares)	(person-days of work/year/farm)						
Less than 0.25							
Family	-4	-2	-2	+1	...	+57	+50
Hired	0	0	-5	0	...	+6	+1
Total	-4	-2	-7	+1	...	+63	+51
0.25-0.50							
Family	-11	-6	+4	0	+2	+61	+50
Hired	+5	-2	+2	+2	+2	+26	+35
Total	-6	-8	+6	+2	+4	+87	+85
0.50-1.00							
Family	-9	-6	-15	+1	+7	+58	+36
Hired	-4	-1	-1	-4	+1	+42	+33
Total	-13	-7	-16	-3	+8	+100	+69
1.00 or more							
Family	-9	+2	-11	+3	0	+62	+47
Hired	+9	-5	-10	+7	+15	+42	+58
Total	0	-3	-21	+10	+15	+104	+105
All sizes ^b							
Family	-9	-4	-9	+1	+3	+59	+41
Hired	+2	-2	-3	+1	+5	+37	+40
Total	-7	-6	-12	+2	+8	+96	+81

Source: Computed from data from Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Includes tree crops and fruits.

^b Weighted by the distribution of farm-size classes.

average half of their land with maize and beans. Although this is significantly less than nonmember farmers, it is still a large proportion. No obvious technical reason exists why farmers should not further expand their export vegetable area, as suitable land remains in reserve (Table 15). Hired labor is available in the region to fill increased labor demand. In the smallest farms, underemployed family labor or family labor seeking off-farm employment could be drawn into the export crops, since average returns per workday are much higher than the prevailing market wage rate (Table 13). This production behavior can be hypothesized as driven by the concern of farmers about risk of the new crops (the potentially high absolute losses per unit of land were discussed above) and the household's desire for food security.

A household is in a secure food situation when it always—throughout the seasons and over the years—has the ability to acquire the food needed to maintain the health of all its members. In farm households, household-level food security may be achieved by own food production and related stockholding, or by relying on open-market trading of food and nonfood production to generate income (and savings), or partially by seeking off-farm, income-earning possibilities. The level and mix of these alternatives depend upon a household's resource endowments, including human capital; the type of market integration for agricultural produce, food, and labor; and the extent to which public institutions (intervention schemes) or community-level institutions (villages, extended family) play a role in providing basic levels of food security in view of unforeseeable circumstances. It is obvious that with decreased institutional provision of food security, lower security of off-farm employment opportunities, and more instability of the agricul-

tural produce and food market, the food security burden shifts toward own production and stockholding. The historical record of food security in the Western Highlands suggests that these are the driving forces that lead farm households to maintain high levels of staple food production for direct household consumption. The survey region as a whole is, however, not self-sufficient. About 50 percent of maize consumed in the six survey villages consists of net imports into the region (Table 21). Self-sufficiency in maize is 67.7 percent among cooperative members and 53.4 percent among nonmembers.

Public institutions cannot ensure effective response to household or local crisis situations. The food and agricultural produce markets are very unstable, as is the labor market. It can thus be hypothesized that farm households operating below or at the margin of food security provided from own food production put a risk premium on nonfood income-earning alternatives. This risk premium—or food insurance premium—that farm households are indirectly paying is represented by the difference between the actual market price of staple food and the shadow cost of production of staple food at the margin. Clearly, the shadow cost of staple food production increases when the opportunity costs of land and labor increase as a consequence of introduction of a new cash crop that yields higher returns to land and labor. To what extent this occurs in the case studied here will be evaluated with a farm model later in the chapter. Before this normative aspect is discussed, another question will be addressed: What actually happened to food production when the new export vegetables were introduced?

Practically all export crop producers (94 percent) maintain some maize production. Ninety-seven percent of the other sample farmers grow maize. Farm households were asked in the 1985 survey what the three most important reasons are for them to grow maize. By far the most important reason stated was "to always have food" (Table 22). Differences between export crop producers and other farmers are small in this respect. The second most important reason, tradition ("we always did it like that"), was followed by the perception that "other crops are risky" and the statement that "maize is profitable." Much has been written about traditional and religious motivations of Western Highlands farmers for growing maize.¹⁵ While most farmers do not give up their *milpa* (cornfield) and plant it with something else altogether, their attitude toward maize and its importance in the production program obviously undergoes change. The introduction

Table 21—Consumption of own production and net purchases of maize in cooperative member and nonmember households, 1985

Households	Consumption of Own-Produced Maize*	Net Purchases of Maize
	(percent of maize consumption)	
Cooperative members	67.7	32.3
Nonmembers		
Farmers	53.4	46.6
Nonfarm households	...	100.0
Weighted average for the six cooperative villages	50.4	49.6

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

* Excluding use for animal feed.

¹⁵ A comprehensive piece is, for instance, Bossen 1984; insights are also provided by Gladwin 1983, 146-147.

Table 22—Farmers' attitudes toward growing maize

Stated Reason for Growing Maize	Ranking of Reasons					
	Cooperative Members			Nonmembers		
	Most Important	Second	Third	Most Important	Second	Third
	(percent of responses)					
To always have food	84	10	2	86	11	...
We always did it like that	3	57	15	1	57	19
Other crops are risky	1	7	16	...	8	12
Maize is profitable	...	2	9	...	5	6
Other	9	12	7	11	10	7
Not applicable	3	12	51	2	9	56

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

of new export crops plays a role in this context, and at the same time, the adoption of new crops is affected by these attitudes. This was already apparent in the adoption model (Table 10) and is further revealed when the reasons stated for growing maize are compared for early versus late adopters of new export crops. Long-term members of the cooperative are more concerned about own-produced maize supply than are new members (Table 23). Also, the early adopters have been or have become less traditional in their decisionmaking on production; the importance of tradition decreases with duration of membership in the cooperative. Long-term members also view other crops as less risky than do new members.

This change in attitude patterns does *not* lead to a reduction in maize availability from own production for consumption. In fact, when corrected for farm size, the majority of export crop growers tend to have similar or higher amounts of maize available for consumption from own produce than other farmers (Table 24). Despite reductions in area and labor inputs to maize, household-level production is maintained because of higher yields of the staple food per unit of land. Cooperative members' maize yields are 30 percent higher on average than those of nonmembers (Table 25). However, because of higher shares of land use for beans, the nonmembers have in the aggregate a somewhat greater subsistence-food availability (maize and beans together) than the members.

Table 23—Reasons for growing maize stated by farmers, by duration of cooperative membership

Reason ^a	Years of Membership in Cooperative		
	More than 5 Years	3–5 Years	Less than 3 Years
	(percent)		
To always have food	92	89	82
We always did it like that	51	62	64
Other crops are risky	9	20	23

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^aOne, two, or three reasons could be stated; therefore, the percentages do not add up to 100 (see Table 22).

Table 24—Production of subsistence maize and use for consumption in farm households, 1985

Farm Size (hectares)	Cooperative Members		Nonmembers	
	Production	Used for Own Consumption ^a	Production	Used for Own Consumption
		(kilogram/adult equivalent) ^b		
Less than 0.25	48	41	59	49
0.25–0.50	103	88	95	82
0.50–1.00	131	113	127	97
1.00 or more	182	137	180	138
Average	142	115	109	87

Source: Computed from data from Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Calculated from a complete production and disappearance balance (production minus sales, losses, animal feed, gifts, seed).

^b Adult equivalents are based on calorie requirements of persons in the household by age and sex.

The two surveys of the same farms permit a comparison of farmers' maize yields once they had moved from nonmember to member status and from recent to long-term members. Maize yields were substantially higher in 1985 than in 1983 in all groups. Climatic conditions played a role in these yields. As shown below, the increase was highest in the group consisting of cooperative members who had joined 3 to 4 years earlier and above average in the group who had joined 5 to 6 years earlier.

Status of Group	1983-85 Change in Kilograms per Hectare
Nonmembers in 1983 and 1985	+ 272
Members since 1984 or 1985	+ 45
Members since 1982 or 1983	+ 456
Members since 1980 or 1981	+ 314

By far the lowest yield increase is in the group of cooperative members who had joined most recently. Their yield increase is even below that of nonmembers. This pattern gives some insights into the dynamics of maize yields in the context of increased export crop production: initially, yields per hectare stagnate or may even drop when the farmer gives much of his attention and resources to the new crops, thus pushing maize onto the more marginal land of his farm. A couple of seasons later, maize yields apparently do catch up. Appropriate program and policy packages that help farmers to speed up in catching potential positive spillover effects from new cash crops to subsistence crops may have high returns and assist in ensuring against household-level food insecurity.

A combination of factors is responsible for the maize yield increases among cooperative members. Fertilizer inputs increased by an average of 6 percent and cropping practices are more labor-intensive among members. Total labor input to staple foods decreases, but labor input per unit of land is increased by 18 percent (mostly for more weeding). Much of the additional weeding labor is hired. Despite increased inputs (fertilizer) and labor, cooperative members produce maize at lower average cost per unit of output. When the cost of family labor is estimated with the prevailing wage rate, members produce a ton of maize for Q189, while nonmembers produce a ton for Q214. Thus, members appear to be more efficient—whether they were so before

Table 25—Yields of subsistence food crops on cooperative member and nonmember farms, 1985

Farm Size	Cooperative Members		Nonmembers	
	Maize	Beans	Maize	Beans
	(metric tons/hectare)			
Less than 0.25	(2.3)	(1.1)	1.8	0.5
0.25–0.50	2.4	(0.7)	1.7	1.5
0.50–1.00	2.1	1.2	1.5	0.6
1.00 or more	2.2	1.8	1.7	0.8
Average	2.2	1.3	1.7	1.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Figures based on less than 10 observations are in parentheses.

joining the scheme or became more efficient through joining the scheme is an issue addressed in more detail below. Both of the above cost figures come close to the prevailing farmgate selling price of maize, which was Q210 on average in the 1985 sample period. Average costs are not much different from marginal cost in this production system.

A closer look at the subsistence crops-export vegetable interaction is provided in the following production function and a programming-model analysis. The objective of this analysis is to assess *competition and complementarity* between the new crops and the subsistence crop (maize) in particular. The approach will be briefly described at the outset.

Crop production (q) is technically a result of area (a) times yield (y) of a crop (i):

$$q_i = a_i \cdot y_i. \quad (5)$$

Choices on the use of inputs, technology, and the amount and quality of land for a certain crop are joint decisions. Acknowledging the problem of separating these decisions, competition between crops can be built into an area allocation function, while input-output relations may be assessed on a per unit of land basis in a yield function.

$$a_i = b_{ij}X_j, \text{ and} \quad (6)$$

$$y_i = b_0 + b_{im}X_m, \quad (7)$$

where b_{ij} and b_{im} are the parameters of the area allocation and yield function of the respective exogenous variables X_j and X_m . While the X_j in the area allocation model is mainly describing economic environment and depicts the related response of farmers, the X_m in the yield model covers technical input-output relationships.

It is hypothesized that consumption needs (calorie requirements) determine, among other things, that the traditional farm households plant a certain share of their total area with maize. With increased farm size, this "subsistence needs-oriented" determination of the maize area is reduced. The worse the land quality of a farm, the higher the share of land required for maize for subsistence needs, everything else being equal. It is also hypothesized that a more traditional attitude toward maize would lead to an increased share of maize land.

Maize is only to a minor extent a "cash crop," but its area share should be expected to be affected by the relative returns to maize versus new export vegetables after desired subsistence levels are fulfilled along the above-stated hypotheses. It is also expected that membership in the cooperative leads to a decreased maize area share beyond the above-mentioned factors, as the cooperative stimulates the growing of new crops. Finally, village-specific dummy variables are included in the model, since the land-quality variable is based on village-specific comparisons of farmers and not on a generalizable measure.

The estimation results of the area model specified along these hypotheses are in Table 26. The model explains a high share of the variance in maize area allocation (85 percent). The following findings will be highlighted:

1. Production is very much driven by staple food needs; this becomes evident from the highly significant variable representing the calorie requirements of the household (ACU). One additional adult-equivalent unit in the household leads, all else (including farm size) being equal, to an expansion of the maize area share by 6 percentage points. Clearly these semisubsistence households not only (partly) consume what they grow but also base their maize production decisions on consumption requirements.

2. Households with a more traditional attitude toward maize (DMZREAS) have a higher maize area share, but smaller farms plant relatively less area with maize (FSZHA). Both determinants are statistically highly significant.

Table 26—Area allocation to maize and the effects of export vegetable production: regression model

Variable	Parameter	t-Value
DCID5	0.03370	0.647
DCID4	0.09424	1.855
DCID3	-0.03591	-0.892
DCID2	0.12100	2.391
DCID1	0.11986	2.454
RGM	-0.04209	-1.075
MZLANDQ	0.18134	16.542
FSZHA	-0.06416	-2.792
DMZREAS	0.06791	2.238
ACU	0.06005	10.189
MIEM	-0.04272	-1.509

$R^2 = 0.85$, $DF = 337$

Notes: Dependent variable: maize area over total farm size.

- DCID1 . . . 5 = dummy variables for villages 1 through 5 = 1, else = 0;
RGM = ratio of gross margin of new export crops over gross margin of maize;
MZLANDQ = quality of area under maize (1, . . . , 4; 1 = best);
FSZHA = farm size in hectares;
DMZREAS = traditional attitude toward maize = 1, else = 0; 1 = "we grow maize for own consumption because we always did it like that";
ACU = calorie requirements of households (adult equivalents); and
MIEM = membership in the cooperative = 1, else = 0.

3. The worse the land quality (MZLANDQ) the bigger the area share of maize. This is to be expected, as alternative crops have less comparative advantage on such land and households also have absolute targets of maize supply from own production.

4. Cooperative membership (MIEM) tends to decrease the area allocated to maize as expected; the net effect is about 4 percentage points, thus, all else being the same, maize area decreases from 60 to 56 percent. The respective parameter is not highly significant.

5. The ratios between the gross margins of maize and the new export vegetables do not turn out to be significant (RGM). It is probably only in the long run that their obvious role comes into play significantly.

Maize yield models are estimated for the total sample (model 1) and separately for the cooperative member farmers (model 2). Finally, yield model 2 is modified by including the degree of participation in export crop production to assess its effects on maize yields beyond the common production factors (model 3).

A heuristic approach is taken to specification of the yield models. From increased fertilizer use, higher yields are expected though decreasing at the margin. Increased labor input should have positive yield effects. With better education, farmers are expected to make more efficient use of resources and get higher yields. On smaller farms, it is hypothesized, farmers pay more attention to yields beyond the factors mentioned. Yields are expected to be lower on plots of lower land quality.

The estimation results of the yield models formulated along these hypotheses are in Table 27. The main findings of this analysis are as follows:

Table 27—Maize yields and effects of export vegetable production: regression models

Variable	Total Sample		Cooperative Members Only			
	Model 1		Model 2		Model 3	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
DCID5	382.65000	1.729	621.41000	1.844	505.53500	1.512
DCID4	-65.68800	-0.298	23.72200	0.075	67.34400	0.217
DCID3	-6.77190	-0.039	-48.71030	-0.183	-56.24500	-0.215
DCID2	-824.29200	-3.886	23.72290	0.075	-877.94900	-2.527
DCID1	-40.26500	-0.195	513.74800	1.390	-58.24500	-0.215
MZLANDQ	-136.25200	-2.196	-34.01890	-0.265	68.67100	0.518
HHEDUC	33.77700	0.933	155.39500	2.645	162.74200	2.815
LABDAYS1	2.20680	2.081	4.07790	2.517	3.69015	2.307
RAREA34	...	...	...	...	811.23180	2.506
FSZHA	-17.92300	-0.186	-70.33560	-0.482	35.65770	0.238
INPUT1	9.81776	4.021	9.48170	2.144	8.14740	2.095
SQINPUT1	-0.02326	-2.973	-0.02451	-1.820	-0.02445	-1.848
(constant)	1,256.55000	4.449	834.56600	1.873	383.55100	0.810
	R ² = 0.19		R ² = 0.20		R ² = 0.23	
	F = 7.02		F = 3.40		F = 3.75	
	DF = 326		DF = 148		DF = 147	

Notes: Dependent variable: maize yields in kilogram per hectare, 1985.

- DCID5 = dummy variables for villages 1 through 5 = 1, else = 0;
- MZLANDQ = quality of area under maize (1, ..., 4; 1 = best);
- FSZHA = farm size in hectares;
- HHEDUC = years of schooling of head of household;
- LABDAYS1 = total labor days in maize per hectare;
- RAREA34 = area under new export vegetables over total area (ratio);
- INPUT1 = cost of fertilizer per hectare of maize; and
- SQINPUT1 = cost of fertilizer per hectare of maize (squared).

1. Input levels of fertilizer (INPUT1) increase yields as expected, and at decreasing rates as the negative sign of the squared term indicates (SQINPUT1). Fertilizer cost per hectare is used as a proxy for nutrients. Differences between the cooperative members and the total sample are not significant in this respect. One additional quetzal spent on fertilizer yields—calculated at sample means—4.9 kilograms of maize at the margin, which sold for Q0.98-1.23 on the market.¹⁶ This suggests that fertilizer use is in the range of efficient levels.

2. Increased labor inputs (LABDAYS1) have a higher than average positive yield effect on cooperative farms. Although marginal labor productivity in maize is higher among members than for the total sample, marginal returns to labor of Q0.82-1.02 (model 2 with maize price of Q0.20-0.25) in the subsistence crop are at the lowest end of the prevailing wage rates, which were Q2.00-2.50 per day in 1984 for men and Q1.00-2.00 for women.

3. A striking result is that better education significantly shifts the yield function upward in the group of cooperative members but does not do so in general (model 2). Apparently literacy becomes increasingly more relevant for productivity when the farms become more complex with the new export crops included in the production program than it does in general (model 1). This is fully in line with the finding of the specific study on the effects of education on Guatemalan agriculture (Freire 1981, 107-145) that illiterate and literate farmers operate on the same aggregate production function, but literate farmers are technically more efficient than illiterate farmers on more diversified farms.

4. Land quality (MZLANDQ) tends to affect yields as expected; here it becomes clear that separating the area allocation effect from the yield effect of production is useful, as the effect of land quality works in opposite directions in the two functions of the model.

5. A striking effect results from the new export vegetables in the crop production program (RAREA34): the higher the share of new crops in the land use, the higher the maize yields even after accounting for different levels of inputs, labor use, and human capital (model 3). Two explanations for this result come to mind. First, the snow pea crop increases the soil-nitrogen levels, which benefits maize if maize follows in the rotation on that land. Second (and more hypothetical), export crop producers improve crop management, which leads to higher efficiency in input use in maize. This effect is then not captured in the input and labor variables. It is plausible that export vegetable producers, in their desire to increase yields of maize for the purpose of maintaining household food security, eliminate Leibensteinian "x-inefficiencies" tolerated before (Leibenstein 1966). The parameter estimated in the yield function implies that joining the scheme with average allocation of land to the new crops (RAREA34) results in a yield increase by 11 percent above the result from higher fertilizer input and labor use per hectare. The higher yields among cooperative members are to this extent a result of the complementary interaction with the new export crops and not just a result of inherently higher efficiency of members.

To sum up, the analysis on the basis of area and yield functions for the subsistence crop (maize) shows that new export vegetables play a complementary rather than a competitive role in the system. Although maize area is reduced and partly squeezed onto land of lower quality, increased input use (fertilizer and labor), favorable soil-fertility effects of the main new crop (snow peas), and more efficient crop-production practices

¹⁶ Maize prices ranged between Q0.20 and Q0.25 per kilogram in the 1984/85 crop year.

overcompensate for the adverse effects and leave export crop producers with higher yields and total supply levels of the subsistence crop. This finding is in line with findings by Reyes-Hernandez, García, and Campos (1985), who diagnose positive yield-increasing spillover effects for the traditional food crop (maize) in more diversified farm-production systems in the area of Chimaltenango (Western Highlands). In their small sample of farms, maize yields in the diversified systems were about 40 percent higher than in the traditional system.

A Premium for Own-Produced Maize: Model Results

The context in which this interaction between new export vegetables and subsistence crops takes place is not only the field crop operation of the farm enterprise but the farm production-consumption unit. To evaluate the effects of introduction of the new crops on farm households' incentive to provide food security from own production, a linear programming model is constructed.¹⁷ Applying a programming model with a profit-maximizing objective function under constraints does not imply an assumption that the farm households in the Western Highlands are single-minded, short-term profit maximizers. It is recognized that a multitude of objectives exist for farmers that may be only partly captured by the constraints introduced into the model. All evidence from the evaluation of response to crop profitability, however, suggests that small highland farmers are managing their agricultural resources and their own time very efficiently and rationally in an economic sense. Still, opposite conclusions have sometimes been drawn for the highland farmers. Gollas (1977), for instance, concludes (from a Cobb-Douglas production function analysis with results that show a positive marginal productivity of farm labor in view of an assumed general surplus labor situation) that the highland farmers are "poor and inefficient." More careful production function analyses by Marsh, Jameson, and Phillips (1983) and Stein (1982) as well as the assessment of households' flexible response to returns to time inside and outside agriculture by Swetnam (1980) clearly refuted Gollas's "poor and inefficient" conclusion for the traditional farmers of the highlands.

Although only a small proportion of farm households sell subsistence crops (13 percent of all maize producers in the sample sold maize during the year), almost all farm households grow maize for own consumption. The cost of this maize to the farm household is determined by the opportunity cost of the resources used for its production. Obviously the opportunity cost of maize production increased when farmers had the option of growing snow peas. It thus follows that consumption of own-produced maize should have become more costly. To what extent is this actually the case? How did farmers respond to this change in this key shadow price?

The model is based on average data of the 0.50-1.00 hectare farms in the sample. Three versions of a farm model are used for comparative static analysis: model 1 represents the situation before new export crops were introduced; model 2 represents the situation after export crops were introduced, but yield levels and technology in subsistence crops are not changed; and model 3 represents the situation as in model 2, but with actual improved productivity in subsistence crops.

The three model versions are described in the Appendix. The main features of the model are the usual constraints on land and family labor (by season). Inputs (fertilizer, pesticides), hired labor, and input financing are available at exogenously fixed prices.

¹⁷ Average data from the 0.50 hectare and 1.00 hectare farm-size classes are used for the model's coefficients.

Rotational restrictions follow the ones widely accepted by farmers. In all three model versions, household demand for staple food (maize or beans or both) is maintained at the same level as observed in the respective class of sample households. Family labor of men and women—but not children—may also earn income from off-farm employment at a constant wage rate.

In the initial situation (model 1) the shadow cost of maize produced for own consumption is Q0.49 per kilogram (Table 28)—more than twice the average sales price of maize in the respective survey year (Q0.21) and substantially higher than the average purchase price (Q0.26). Clearly, farm households are willing to pay the price in terms of income forgone to have maize from their own fields. The difference between the shadow cost of maize production for own consumption and the actual purchase price of maize can be interpreted as a "food-security insurance premium." In 1985 the premium was Q0.23 per kilogram in farm households that did not grow the new export vegetables. When the new export crops become an option for the farm household, this insurance premium increases drastically—nearly quadrupling, as demonstrated with model 2 versus model 1 (from Q0.23 to Q0.90 per kilogram). Maintaining subsistence production becomes more than twice as costly as before: the shadow cost of maize production increases from Q0.49 to Q1.16 per kilogram. While there was an incentive before, as indicated by the 1985 insurance premium, to bring down the unit cost of production for subsistence, this incentive was much increased by the introduction of competitive export vegetables.

Households have two options in responding to the increased cost of food security provided from own production. They may simply cut back the staple food production or increase its productivity (or a combination of the two). The yield function analysis above demonstrated that they most often choose the latter. This option's effect on the

Table 28—Effects of new export vegetables on shadow cost of subsistence food production and selected other variables

Variable	Model 1 Before Intro- duction of New Export Crop	Model 2	Model 3
		After Introduction of New Export Crop	
		Without Improved Productivity in Subsistence Crops	With Improved Productivity in Subsistence Crops
Land use (hectares)			
Subsistence crops	0.49	0.49	0.35
Traditional vegetables	0.26		
Snow peas	...	0.26	0.40
Family labor			
On-farm } (days in model 1 = 100)	100.00	124.00	165.00
Off-farm }	100.00	84.00	55.00
Share of family labor on farm (percent)	49.30	59.60	75.00
Working capital			
Over year (quetzals in model 1 = 100)	100.00	304.00	441.00
In percent of cash income	24.50	51.40	58.10
Shadow price of land (quetzals/hectare)	456.00	1,455.00	1,455.00
Shadow cost of maize produced for own consumption (quetzals/kilogram)	0.49	1.16	0.84
Difference to average maize purchase price (quetzals/hectare) ("insurance premium")	0.23	0.90	0.58

Notes: These results of programming model scenarios are for an average 0.75-hectare farm based on 1985 survey of farms from 0.50 to 1.00 hectare. See Appendix for descriptions of the three versions of the model.

insurance premium is traced in model 3. Clearly, the cost of maintaining desired household food security through production of staple food for own consumption can be substantially decreased this way (from 0.90 to 0.58, as shown in Table 26). Still, the insurance premium remains higher than in the situation at the outset. The incentive remains high to further increase productivity in staple food production.

The new crops lead to an increased labor and capital intensity in agricultural production. The new export crops require not only more absolute working capital but also more relative capital in percent of total household cash income. Without new export crops, working capital invested in crop production was about one quarter of total cash income (model 1). With the new crops, it amounts to more than half of cash income (58.1 percent, model 3).

With increased productivity of staple food, overall income increases and land is freed for the new export crop that can generate additional income. The income increase made possible by increased productivity of subsistence crops (going from model 2 to model 3) is about as high as the income effect from the pure introduction of the export vegetables without improved productivity in the staple foods (going from model 1 to model 2). This key role of technological improvement in staple food production of farms that have the option of growing new export crops must be understood in order to maximize both income and employment opportunities.

In summary, the following conclusions are stressed from this analysis of the agricultural production effects:

1. Export crops and subsistence crops are complementary rather than competitive in the case studied.

2. Household-level food security through a high level of subsistence food production was maintained or even expanded when new export crops were introduced. While this is understandable and explainable with market failures—that is, failures in the food market and in the labor market on which many of the small farmers with an excess supply of labor depend—this approach to food security does not appear to be the “first-best” economic solution, as indicated by the high “insurance premiums” paid by farm households for own-produced subsistence food. A policy environment that ensures the functioning of food markets without major disruptions is a precondition for farm households to develop confidence in the market and consequently to make use of the advantages of the exchange economy. It is thus a precondition for first-best economic solutions to food insecurity. Options other than food security based on own-produced food exist for the cost-effective provision of food security; for instance, food-related income transfers or employment-oriented measures targeted toward the absolute poor. Such measures would impinge on the observed resource allocation in agricultural production biased toward staple food only if they were perceived as reliable by the poor.

3. The shadow cost of staple food production for own consumption increases drastically as returns to land and labor of the new export crops increase. In view of the prevailing high preference for having maize from the own field for food security reasons, the increased shadow cost of subsistence production did lead to some reduced area allocation to staple food production. However, variable inputs (labor, fertilizer) per unit of land increased. This and positive yield-increasing effects of the new crops in the rotation permit reduction of staple food crop area along with an increase in food output combined with the favorable income and employment effects of the new crops.

4. The Western Highlands farmers were able to adopt this balanced strategy of crop diversification plus intensification of staple food production because of the availability of yield-increasing measures, related input supply channels (seed, fertilizer), and hired

labor. In the absence of these conditions, farmers with strong preferences for subsistence crops will not adopt the export crop. The policy conclusion is obvious: if gains from diversification and export crop production are to be achieved through rapid adoption by small farmers without diminishing their food security in an environment of market failures, farmers must have access to technology to enhance food crop productivity per unit of land.¹⁸

Effects of New Export Crops on Off-Farm Income

The previous chapters concerned production and related income effects. As stated earlier, agricultural income is very much complemented by income from other sources in these communities of the Western Highlands. In fact, it is often the other way around: off-farm income is complemented by farm income in many households.

Patterns concerning sources of income differ by cooperative status (Table 29). In general, nonmembers earn more income as agricultural day laborers and nonagricultural workers than do members. Member households are also active in such off-farm income-earning activities during the year, but they work fewer days off-farm, which explains their lower absolute income from these sources. In addition, income from transfers and remittances is not only higher on average in member households but also more widely distributed. Seventy-five percent of the households reported transfers.

The distribution pattern of income by source suggests that export crop producers withdraw from the off-farm labor market and spend more of their time in agricultural production on their own fields (see also employment effects in Table 20). This reduces

Table 29—Percentage of households receiving income from off-farm activities, by farm size and cooperative membership

Farm Size/ Membership	Source of Off-Farm Income			
	Agricultural Day Labor	Nonagricultural Wages	Nonagricultural Merchant	Transfer Income, Remittances
(hectares)	(percent of households in farm-size group)			
Less than 0.25				
Members	25.0	50.0	12.5	62.5
Nonmembers	53.2	48.9	10.6	55.3
0.25–0.50				
Members	25.0	33.3	13.9	75.0
Nonmembers	40.6	48.4	17.2	57.8
0.50–1.00				
Members	17.8	27.5	19.2	76.7
Nonmembers	13.2	34.2	28.9	57.9
1.00 or more				
Members	7.5	28.3	11.3	75.5
Nonmembers	30.0	20.0	6.7	36.7
All sizes				
Members	16.5	30.0	15.3	75.3
Nonmembers	36.3	40.8	16.2	53.6

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

¹⁸ Similarly, in labor-scarce, land-rich environments, such as parts of Africa, productivity of labor in food production must increase to achieve this desired development effect.

their off-farm earnings. Numerous intervening variables determine the extent to which this actually happens. The following model sheds some light on this.

It is hypothesized that household earnings are determined by available labor; demographic structure; the farm's resource base in relation to household labor force, which determines the opportunity cost of off-farm work; and human capital, which may impinge on the off-farm income-earning possibilities. Local-level labor market conditions, including location of village, may further differentiate the effect of the various factors. An off-farm income-earning function (r) may thus be specified for i households as

$$r_i = a_0 + b_j X_{ij} + b_k X_{ik} + u_i, \quad (8)$$

where

a = intercept,

b_j = the parameters of X_{ij} variables describing the off-farm income-earning potentials,

b_k = the parameters of X_{ik} variables depicting the on-farm income-earning potential, and

u_i = error term.

The results of the model specified along the above-stated hypotheses underscore that off-farm income-earning by farm households is reduced with an increased resource base for agricultural income-earning on the own farm (RFMLAB) (Table 30). The opportunity to grow the new export vegetables with rising returns per unit of family labor can be interpreted as an expansion of the resource base per unit of family labor. Returns to family labor more than doubled those of traditional crop producers and export crop producers (for instance, maize, beans, and traditional vegetables of traditional farmers versus snow peas, broccoli, and cauliflower of export crop producers shown in Table 13). A doubling of the resource base (land per family labor, RFMLAB) would reduce off-farm income-earning by 11 percent at sample means.

Table 30—Determinants of off-farm income: regression model

Variable	Parameter	t-Value	Mean of Variable
RFMLAB	-362.947	-1.71	0.231
HHEDUC	184.600	5.68	3.003
RWOMLAB	-689.430	-2.04	0.463
DCID5	411.807	2.00	0.092
DCID4	100.564	0.48	0.089
DCID3	-327.380	-2.04	0.186
DCID2	-480.957	-2.43	0.102
DCID1	-288.961	-1.44	0.097
(Constant)	683.016	3.58	...

$R^2 = 0.12$, $F = 6.50$, degrees of freedom = 3.62.

Notes: Dependent variable: total nonfarm income per capita per year (quetzals).

RFMLAB = farm size per person of working age available for farm work (in hectares per person),
 HHEDUC = household education (years of school),
 RWOMLAB = share of female labor in total household labor, and
 DCID1 ... 5 = village dummy variables.

The model only implicitly addresses the complex issue of the value of human time and its effect on substitution between off-farm versus on-farm work. People may derive utility from spending less time searching and traveling for off-farm work. Also, the search cost for off-farm employment reduces the net income from such sources. An indication for this is that nonmembers of the cooperative spend relatively and absolutely more on transportation. One quetzal of gross income from off-farm work may therefore be worth less to the household than one quetzal of discounted present value earned on the own farm.

Most important and significant is the influence of education levels on off-farm earnings (HHEDUC). Thirty percent of the explained variance is a result of this variable. In the simple model specification, the parameter estimate suggests that one additional year of schooling of the household head raises off-farm income, all else being equal, by 25 percent. It should be recalled that higher levels of human capital were also found to raise labor productivity in agriculture once the production system becomes more complex with new technologies and the new cash crops (see Table 27). Investment in human capital is thus shown here to shift both the agricultural and the nonagricultural income-earning capacities.

Although more available labor per unit of land increases a household's per capita off-farm earnings, an increased share of female labor (RWOMLAB) decreases it. Off-farm income-earning opportunities are less favorable for women in the area, and women's wages tend to be lower than men's in agricultural work by 20 to 30 percent.

The village dummy variables test for the difference with Santiago, which is the largest community and provides the most opportunities. As expected, most of the village dummy variables for the other communities are significantly negative.

The result of this analysis suggests that the net increase in farm income from the new export crops is not identical with the net increase in total income. The increase in total income is diminished by reduced off-farm income, since households withdraw partly from off-farm income earning once they adopt the new export vegetables, for which they allocate more of their time to on-farm work.

EFFECTS OF THE NEW EXPORT CROPS ON EXPENDITURES, CONSUMPTION, AND NUTRITION

Surveys on income—especially direct approaches to income assessment rather than indirect ones via disaggregated accounting of costs and returns, as in this study for agricultural income—suffer from both inaccuracy and high intertemporal fluctuations that do not represent the long-term standard of living of households. This is particularly true in the Western Highlands, where high shares of off-farm income may have significant fluctuations over time. Expenditures on food and nonfood, including the value of home-produced food, represent a more stable indicator of households' permanent income standard.

The following analysis of expenditures has two main purposes: first, to evaluate the effects of the new export crop production on levels of expenditures (using total expenditures as an income proxy); and second, to assess the effects of changes in income levels and the nature of the income stream on the composition of expenditures. Of special interest are questions such as, What happens to the composition of the diet once households earn more income from the export crop? or, Do poor households increase their spending on "luxury items" when they earn more cash income from cash crops than in-kind income from increased subsistence food production?

This analysis is based on the complete expenditure surveys on all food and nonfood items for September 1983 and September 1985. Only the 1985 survey includes foods consumed from own production and an annual expenditure survey on durables and less-frequent expenditures, such as for housing, education, health, feasts, and clothes. The following comparative evaluation between 1983 and 1985 is based on the strictly comparable monthly cash expenditure surveys. Analysis based only on the 1985 survey draws on the full expenditure survey, including own-produced food consumed in the household and items from the annual expenditure survey. This approach was taken to use a maximum of information from the longitudinal comparisons, while presenting the complete picture from the more detailed 1985 survey.¹⁹

Income Effects in Relation to Farm Size and Income Distribution

As shown in the table below, the 1985 cross-sectional comparison suggests that export crop production increases relative income the most in the smallest farm-size classes and thus contributes to a more equal income distribution among the poor. Farm households with more than 1 hectare and who depend more on hired labor for additional labor input actually capture comparatively less benefit from new export vegetable production.

¹⁹ This explains the difference between the 1985 figures in the comparative tables and the 1983 data below versus the 1985 figures in the other tables.

Farm Size	Difference in per Capita Expenditure of Members Versus Nonmembers
Less than 0.25	+ 59.8
0.25-0.50	+ 33.1
0.50-1.00	+ 20.2
1.00 or more	+ 3.4

During the two-year period between the surveys, the distribution pattern of expenditures changed only slightly. This does not mean, however, that the situation of households in poverty in the area is a static one. To what extent did the same households remain static or move upward or downward in terms of real per capita income and what is the role of new export vegetables in this respect? The per capita expenditures from 1983 are, for the purpose of this comparison, expressed in 1985 prices.²⁰

Household transitions from one expenditure class to another inside and outside the export crop scheme provide interesting results (Figure 6). For cooperative members among the poorest tercile in terms of per capita expenditures, only 38.0 percent remained in this position from 1983 to 1985, compared with 55.0 percent for nonmembers. A much higher percentage of members moved upward in the expenditure classes and a much lower percentage moved downward. This holds true for the middle and high income terciles. For instance, among members, 30.4 percent dropped from the middle tercile to the lower and 37.5 percent moved to the higher tercile, among the nonmembers in the middle tercile in 1983, 36.7 percent dropped to the lower and 25.0 percent moved to the higher tercile. The whole spectrum of households moved relatively more upward among members than among nonmembers.

Effects on Expenditure Patterns

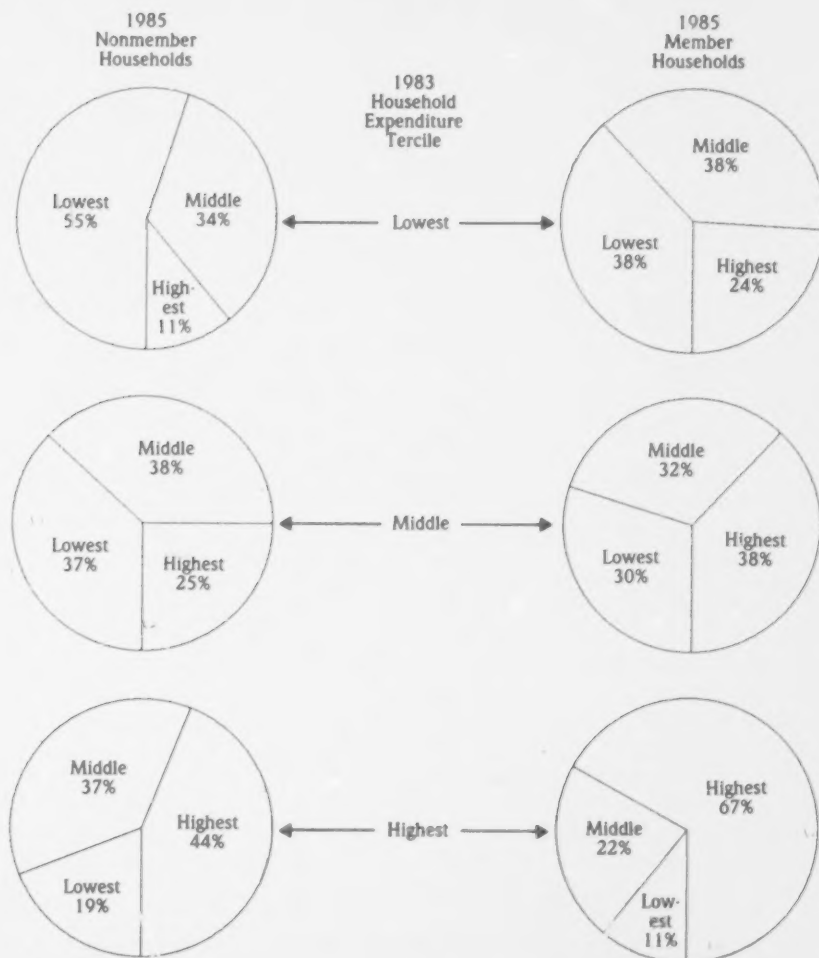
The total expenditures of cooperative members are 20 percent higher than those of nonmembers. The cash expenditures of members on both food and nonfood items and the value of their own-produced food for home consumption are higher. Members' nonfood expenditures are 32 percent higher and the imputed value of the own-produced food for home consumption is 8 percent higher. Even after controlling for farm size, food purchases of members are higher than those of nonmembers. For example, member households with farms of 0.5-1.0 hectare spend 15 percent more per capita on purchased food than nonmembers in the same farm-size group.

Although the absolute food expenditures of cooperative members are greater than those of nonmembers, the share of the budget that members devote to food items is lower. Members spend on average 64 percent of total expenditures on food compared with 67 percent among nonmembers (Table 31).

A more detailed breakdown of household expenditure patterns reveals that relative differences between export crop producers and other farm households are not substantial (Tables 32 and 33). For food items other than meat, eggs, and fish, cooperative members spend relatively less than nonmembers. This implies that income elasticities

²⁰ The reported general inflation rate in Guatemala was 4 percent in 1984, 19 percent in 1985, and 23 percent in 1986. The inflation rate measured in the noncooperative households, which are the majority of households at the location, was used to derive the location-specific inflation rate (33.6 percent over the two-year period).

Figure 6—Transition of cooperative member and nonmember households between expenditure terciles from 1983 to 1985



Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Expenditures are in constant 1985 prices.

for meat, eggs, and fish are above unity and for other food items are below unity. For some of the main staple foods—for example, maize and beans—members also spend absolutely less. It should be noted that this may partly reflect price differences rather than quantity differences. This issue is further addressed later in the food consumption analysis. Also, in 1983, the simple comparison of expenditure patterns of the two groups does not reveal striking differences (Table 34). The direction and magnitude of the differences between item-specific budget shares of members and nonmembers are as expected.

Table 31—Expenditures on foods (purchased and own-produced) and nonfoods, by farm size and duration of cooperative membership, 1985

Group	Food, Purchased		Food, Own-Produced		Nonfood		Total Expenditures	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
By farm size (hectares)								
Members								
Less than 0.25	267.76 ^a	55.5	36.30 ^a	7.5	178.92 ^a	37.0	482.97 ^a	100.0
0.25–0.50	239.86	59.7	37.71	9.4	124.12	30.9	401.69	100.0
0.50–1.00	240.30	49.8	57.08	11.9	184.85	38.3	482.24	100.0
1.00 or more	221.36	48.1	53.07	11.5	185.84	40.4	460.27	100.0
Total average	233.77	52.7	50.06	11.3	159.59	36.0	443.42	100.0
Nonmembers								
Less than 0.25	185.64	61.4	22.77	7.5	93.87	31.1	302.27	100.0
0.25–0.50	182.08	60.2	31.90	10.5	88.53	29.3	302.51	100.0
0.50–1.00	208.83	52.0	52.92	13.2	139.64	34.8	401.39	100.0
1.00 or more	212.89	47.8	55.05	12.3	177.92	39.9	445.87	100.0
Total average	204.82	57.0	35.05	9.8	119.45	33.2	359.32	100.0
By years of membership								
Less than 2 years	237.97	51.4	44.07	9.5	181.36	39.1	463.41	100.0
2–4 years	222.17	53.4	54.30	13.0	140.02	33.6	416.49	100.0
5–6 years	244.99	50.4	52.11	10.7	188.94	38.9	486.05	100.0
Total average	233.77	52.7	50.06	11.3	159.56	36.0	443.42	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Parts may not add to totals because of rounding.

^a There are only 6 observations in this group; in all other groups, at least 25 observations are the basis of the mean values listed.

Between 1983 and 1985, total expenditures at 1985 constant prices for all purchased items (excluding own-produced food) increased by nearly the same rate in member and nonmember households (5.1 and 5.0 percent, respectively). (See Tables 35 and 36.) However, cooperative members spend substantially more on housing and land purchases, which cannot be included in this comparison, as the 1983 baseline does not exist. The annual recall for 1985 showed 84 percent higher spending for land purchases by member households, which may be indicative of a higher savings rate in those households. This expenditure-savings pattern may also be a reason for the higher increase in expenditures among the recent export crop producers versus households that have been in the scheme longer. The introduction of new export vegetables leads to increased consumption of food and nonfood expenditures, especially in the first years of membership. Total expenditures of new members who entered the scheme between the two surveys increased by 33.1 percent and food expenditures went up by 13.8 percent. For members in the scheme longer, consumption expenditures either increased less substantially, or in the case of medium-term members (3–4 years), even dropped in real terms. This pattern is a function of the one-time reallocation of resources to export vegetables and higher returns to land and labor. Once this specialization effect is achieved, further growth is constrained by resource endowments and lack of new technology.

It is noteworthy that landless households' total expenditures dropped in real terms by 1.3 percent (Table 36). Contraction in overall employment in Guatemala and reduced real wage rates during the economic crisis in the mid-1980s greatly affected this group. The favorable employment effects from export vegetables in the cooperative area have

Table 32—Food (including own-produced) and nonfood expenditures of cooperative members, 1985

Commodities, Other Items	Value of Purchases per Capita per Year		Value of Consumed Own Produce per Capita per Year		Total per Capita per Year	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
Maize	15.59	4.0	26.93	53.8	42.52	9.6
Other cereals, bread	39.76	10.1	...	...	39.76	9.0
Pulses	15.72	4.0	6.80	13.6	22.52	5.1
Sugar	14.67	3.7	...	...	14.67	3.3
Roots, tubers, bananas	10.73	2.7	1.11	2.2	11.85	2.7
Vegetables, fruits	27.45	7.0	9.86	19.7	37.31	8.4
Milk products	9.01	2.3	2.33	4.7	11.33	2.6
Meat, eggs, fish	73.23	18.6	2.91	5.8	76.13	17.2
Fat, oil	6.26	1.6	0.12	0.2	6.38	1.4
Other foods	3.34	0.8	...	...	3.34	0.8
Nonnutritious foods, beverages	18.01	4.6	...	...	18.01	4.1
Total food	233.77	59.4	50.06	100.0	283.83	64.0
Fuel, energy	26.30	6.7	...	...	26.30	5.9
Clothing	22.76	5.8	...	...	22.76	5.1
Home articles	11.62	2.9	...	...	11.62	2.6
Hygiene, cosmetics	24.18	6.2	...	...	24.18	5.5
Education	0.55	0.1	...	...	0.55	0.1
Health	13.19	3.4	...	...	13.19	3.0
Transportation	20.27	5.2	...	...	20.27	4.6
Entertainment	3.15	0.8	...	...	3.15	0.7
Loans, transfers, donations	11.16	2.8	...	...	11.16	2.5
Other services	26.42	6.7	...	...	26.42	6.0
Total nonfood	159.59	40.6	...	...	159.59	36.0
Total expenditures	393.36	100.0	50.06	100.0	443.42	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Data are based on one-month recall, September 1985. Parts may not add to totals because of rounding.

apparently not counterbalanced these effects for the landless in the sample but certainly reduced the adverse effects of the economic crisis.

A number of factors determine how scarce resources are allocated by poor households to food consumption versus other consumer goods. To test the extent to which the source of income along with other factors impinges on the budget share allocated to food, a model is specified for estimation of Engel curves that includes relevant sources of income (their relative shares) as explanatory variables together with the level of income. Also, household size is controlled for to account for potential scale effects. Three sources of income are distinguished—income earned from the new export crops, male income earned off-farm, and female income earned off-farm. The hypotheses to be tested are that income earned under men's control (off-farm and from the new export vegetables) is relatively less spent on food than farm income in general, and female-controlled income earned off-farm is relatively more spent on food than general household income. Total expenditure is used as a proxy for expected permanent income in this analysis. It is noted that this is not entirely satisfactory because of the simplistic assumptions regarding savings.

Three different models are specified to evaluate the hypotheses. The first model includes members and nonmembers and tests whether the cooperative has an institutional effect after controlling for the relative income-share effect from the new crops. Institutional arrangements such as cash payment schemes, savings opportunities, and

Table 33—Food (including own-produced) and nonfood expenditures of nonmembers of cooperative, 1985

Commodities, Other Items	Value of Purchases per Capita per Year		Value of Consumed Own Produce per Capita per Year		Total per Capita per Year	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
Maize	22.90	7.1	21.18	60.4	44.08	12.3
Other cereals, bread	31.63	9.7	0.01	0.0	31.65	8.8
Pulses	18.13	5.6	3.72	10.6	21.85	6.1
Sugar	12.16	3.7	...	...	12.16	3.4
Roots, tubers, bananas	9.25	2.9	0.60	1.7	9.85	2.8
Vegetables, fruits	23.43	7.2	7.06	20.2	30.49	8.5
Milk products	8.00	2.5	0.48	1.4	8.48	2.4
Meat, eggs, fish	56.68	17.5	1.95	5.6	58.63	16.3
Fat, oil	5.25	1.6	0.05	0.1	5.30	1.5
Other foods	1.92	0.6	...	...	1.92	0.5
Nonnutritious foods, beverages	15.47	4.8	...	...	15.47	4.3
Total food	204.82	63.2	35.05	100.0	239.87	66.8
Fuel, energy	22.36	6.9	...	...	22.36	6.2
Clothing	15.29	4.7	...	...	15.29	4.3
Home articles	5.01	1.5	...	...	5.01	1.4
Hygiene, cosmetics	22.76	7.0	...	...	22.76	6.3
Education	0.56	0.2	...	...	0.56	0.2
Health	10.45	3.2	...	...	10.45	2.9
Transportation	22.76	7.0	...	...	22.76	6.3
Entertainment	3.77	1.2	...	...	3.77	1.0
Loans, transfers, donations	0.98	0.3	...	...	0.98	0.3
Other services	15.52	4.8	...	...	15.52	4.3
Total nonfood	119.45	36.8	...	...	119.45	33.2
Total expenditures	324.27	100.0	35.05	100.0	359.32	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Data are based on one-month recall, September 1985. Parts may not add to totals because of rounding.

household extension activities may have an effect on the budget share allocated to food. The same model is then estimated separately for members and nonmembers to test for additional differences in spending behavior between the two groups. The results of this analysis are in Table 37.

Food expenditures as a proportion of total expenditures decrease significantly, but not rapidly, with increased income. At total sample mean, a 10 percent increase in total expenditure decreases the budget share to food by only 0.21 percent (computed from Table 37). The dummy variable for separating the cooperative members (MIEM), which is included in the model for the total sample, is not statistically significant. Thus, once income levels and sources are controlled for, membership does not seem to have a distinct effect on shifting the budget share for food. At the margin at higher income levels, however, the budget share to food decreases more rapidly with rising income in member households than in nonmember households (see LTEXPCSQ in the three models, Table 37).

There are indications from anthropological research in the study area that male-controlled income is spent more according to men's preferences than women's and more food may not rank high among men (Nieves 1987, 32). The variables related to income source indicate in this analysis that an increased share of income from new export vegetables (RCASH) decreases the budget share to food beyond the total income effect in cooperative member households. The effect is, however, not highly statistically

Table 34—Food (excluding own-produced) and nonfood expenditures of cooperative members and nonmembers, 1983

Item	Annual per Capita Value of Purchases			
	Members		Nonmembers	
	(quetzals)	(percent)	(quetzals)	(percent)
Maize	13.71	4.9	14.76	6.4
Other cereals, bread	40.68	14.5	38.32	16.6
Pulses	10.11	3.9	7.95	3.4
Sugar	12.61	4.5	11.19	4.8
Roots, tubers, bananas	8.36	3.0	7.16	3.1
Vegetables, fruits	14.56	5.2	10.92	4.7
Milk products	6.05	2.2	5.76	2.5
Meat, eggs, fish	43.55	15.5	37.85	16.4
Fat, oil	4.35	1.6	3.71	1.6
Other foods	3.15	1.1	2.90	1.3
Nonnutritious foods, beverages	14.33	5.1	11.31	4.9
Total food	171.46	61.2	151.85	65.7
Fuel, energy	15.32	5.5	12.65	5.5
Clothing	33.09	11.8	13.37	5.8
Home articles	6.74	2.4	3.94	1.7
Hygiene, cosmetics	12.69	4.5	11.76	5.1
Education	0.42	0.1	0.00	0.0
Health	7.44	2.7	6.91	3.0
Transportation	7.79	2.8	14.24	6.1
Entertainment	1.08	0.4	1.24	0.5
Loans, transfers, donations	4.23	1.5	0.00	0.0
Other services	19.81	7.1	15.13	6.5
Total nonfood	108.61	38.8	79.24	34.3
Total expenditures	280.07	100.0	231.09	100.0

Source: Institute of Nutrition of Central America and Panama survey, 1983.

Notes: Data are based on one-month recall, September 1983. Parts may not add to totals because of rounding.

significant. If, for instance, the income share from new cash crops increases from 0 to 50 percent, the food budget share is reduced by 1.2 percentage points, holding income constant.

This analysis also shows that the net effect for the food budget share of an increased income share of new export crops is very similar to the net effect of an increased share of male nonagricultural income (see the parameters for RCASH in the cooperative member model and for RMNAGINC in the nonmember model in Table 37). On the other hand, women's share in total off-farm income (RFNAGINC) does not appear to have an effect on the budget share to food beyond total income.

Of Q100 of incremental income, cooperative members in the lowest income quartile spend Q52.7 on food, but nonmembers spend Q61.0 on food (Table 38). The estimates of the marginal food expenditures within expenditure quartiles by members and nonmembers show generally lower values for the members within the same expenditure groups. These estimates also point to an interesting relationship between income (total expenditure) and marginal food expenditures. In the poorest quartiles, both members and nonmembers spend less of incremental income on food than the second quartile (in the case of members, even less than the third quartile). Apparently, the poorest households have a high propensity to spend on goods and services other than food at the margin. This expenditure pattern may originate from fixed expenditure obligations for nonfood necessities. As shown in Chapter 7, this expenditure behavior may still be consistent with a high income elasticity of calorie consumption among the poor.

Table 35—Food and nonfood per capita expenditures of cooperative members and nonmembers, 1983 and 1985

Group	Expenditures per Capita					
	Food		Nonfood		Total	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
1983						
Landless	257.30	54.8	212.00	45.2	469.30	100.0
Members by years of membership ^a						
2 or less	209.87	66.3	106.84	33.7	316.71	100.0
3-4	225.08	60.7	145.94	39.3	371.02	100.0
5-6	248.16	58.7	174.33	41.3	422.49	100.0
Total average for members	229.07	61.2	145.10	38.8	374.17	100.0
Total average for nonmembers	202.87	65.7	105.86	34.3	308.73	100.0
1985						
Landless	270.83	58.5	192.15	41.5	462.93	100.0
Members by years of membership ^a						
2 or less	238.76	56.6	182.86	43.4	421.63	100.0
3-4	222.17	66.1	113.77	33.9	335.94	100.0
5-6	246.29	57.1	184.96	42.9	431.25	100.0
Total average for members	233.77	59.4	159.59	40.6	393.36	100.0
Total average for nonmembers	204.82	63.2	119.45	36.8	324.27	100.0

Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Data exclude own-produced food consumed in the household, as the 1983 survey does not include related information. All data are in 1985 prices. Parts may not add to totals because of rounding.

^a Years of membership in the cooperative as of 1985.

Table 36—Change in per capita expenditures, by cooperative membership and duration of membership, 1983-85

Category	Cooperative Members		Nonmembers	
	Change in Total Expenditures	Change in Food Expenditures	Change in Total Expenditures	Change in Food Expenditures
	(percent)			
Landless	...	...	-1.3	+ 5.3
Cooperative members by years of membership				
2 or less ^a	+ 33.1	+ 13.8	...	...
3-4	-9.5	-1.3	...	...
5-6	+ 2.1	-0.8	...	...
Total average	+ 5.1	+ 2.1	+ 5.0	+ 1.0

Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Value of own-produced food is not included here, as the 1983 survey did not include these items. In 1985 the value of own-produced food was 13 percent of total household expenditures for cooperative members and 11 percent for nonmembers.

^a This group became members in the cooperative two years or less before 1985; thus they entered the cooperative after the 1983 survey.

Table 37—Determinants of budget share to food in cooperative member and nonmember households, 1985: regression model

Variable	Total Sample		Nonmembers		Members	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
HHSZ	0.003765	1.424	0.005195	1.462	0.002795	0.704
RCASH	-0.023010	-1.691	-0.018140	-1.047	-0.038070	-1.655
RFNAGINC	0.009191	0.261	0.018070	-0.411	-0.007464	-0.104
RMNAGINC	-0.023100	-1.706	-0.033500	-2.263	0.020290	0.578
MIEM	0.010550	0.797				
LTEXPC	0.279710	1.861	0.156420	0.913	0.579280	1.821
LTEXPCSQ	-0.035270	-2.809	-0.024610	-1.694	-0.060220	-2.314
(Constant)	0.248630	0.557	0.596770	1.193	-0.630700	-0.650
	R ² = 0.34		R ² = 0.37		R ² = 0.33	
	DF = 342		DF = 178		DF = 158	
	F = 25.6		F = 17.7		F = 12.8	

Notes: Dependent variable: budget share to food.

- HHSZ = household size (number of persons);
- RCASH = ratio of income from new export vegetables over total income (total expenditure is used as proxy for expected total income);
- RFNAGINC, RMNAGINC = ratio of female (male) nonagricultural off-farm income over total income (total expenditure is used as proxy for expected total income);
- MIEM = membership in cooperative (1 = members, else = 0);
- LTEXPC = log of per capita total expenditures serving as a proxy for expected (permanent) income; and
- LTEXPCSQ = LTEXPC squared.

Effects on Calorie Consumption

The problem of protein-energy deficiency of the rural poor in Guatemala is well researched (see, for example, Balderston et al. 1981; Mata 1978). It is, therefore, not the objective of this research to comprehensively evaluate the nature and prevalence of food deficiencies and malnutrition but to assess the direction and magnitude of changes in consumption and nutrition due to increased export crop production in smallholder households.

Differences in food availability in the Western Highlands households are closely related to income. This is to be expected at such low levels of income. If the sample is grouped into four equal groups by total expenditure per capita (including the value of home-produced food consumed), the lowest quartile had less than two-thirds of calories per adult equivalent unit as the highest quartile (Table 39). Within the Western Highlands, the degree of poverty as reflected in levels of food availability in households indicates a considerable degree of inequality among the poor. It should be noted that calorie availability for this assessment is based on monthly purchases of food and food from own production used for home consumption. This rough approach to food consumption is likely to result in higher calorie per capita figures than an accounting of actual food intake, since losses in storage and processing and losses due to waste are not included. Ideally, actual food intake of individual family members would be preferred in view of findings from earlier research in Guatemala that suggest the income-food intake relationship (calories) is more pronounced among children (preschoolers) than

Table 38—Incremental expenditure on food by cooperative member and nonmember households, by expenditure quartile, 1985

Expenditure Quartile	Share of Incremental Expenditure on Food	
	Members	Nonmembers
	(percent)	
Lowest	52.7	61.0
Second	70.4	76.6
Third	58.1	57.0
Highest	31.9	44.5

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: The estimates of the presented marginal shares of food expenditures are based upon the following regression model estimated separately for each of the groups and quartiles: food expenditure per capita = $f(\text{HHSZ}, \text{LTEXPC}, \text{RCASH}, \text{RFNAGINC}, \text{RMNAGINC})$,

where

- HHSZ = household size (number of persons);
- LTEXPC = log of per capita total expenditures serving as a proxy for expected (permanent) income;
- RCASH = ratio of income from new export vegetables over total income (total expenditure is used as proxy for expected total income); and
- RFNAGINC, RMNAGINC = ratio of female (male) nonagricultural off-farm income over total income (total expenditure is used as proxy for expected total income).

Table 39—Food availability and composition of food consumption by expenditure quartiles (mean values) in the sample, 1985

Category	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
	(per capita)			
Average of 1985 expenditures (quetzals) ^a	186	283	410	771
Calorie availability per adult equivalent per day				
Cooperative members	2,214	2,563	3,088	3,446
Nonmembers	2,122	2,680	3,101	3,401
Total average	2,153	2,628	3,094	3,429
Percent of total calories ^b				
Maize	57.2	57.0	54.6	49.4
Other cereals	6.1	7.4	5.7	6.8
Pulses	9.0	8.3	8.2	7.3
Sugar	13.7 ^a	11.7	10.7	11.8
Meat, eggs, fish	4.8	5.6	6.5	7.4
All other foods and beverages	9.2	10.0	14.3	17.3
Total (percent)	100.0	100.0	100.0	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Includes the value of own-produced food consumed by the household.

^b Average of total sample.

for the household as a whole (Flores 1975, 10). To the extent that Flores's finding based on survey data from the 1960s is still valid, the household income-calorie consumption relationship for preschoolers is assumed to be even higher than the total household averages presented here.

More than half of the available calories in households are from maize, but this share decreases with increasing income (Table 39). Also, the calorie share of pulses (mainly beans) decreases, while the share of meat, eggs, fish, and other food calories increases with higher income. Accordingly, the price per calorie increases with rising income as the diet becomes more diversified. Cooperative members spend an average Q0.265 per 1,000 calories, while nonmembers spend Q0.240 per 1,000 calories, or 10 percent less.

Comparison of food availability between export vegetable-producing households (cooperative members) and other households shows that the latter acquire, on average, about 7 percent fewer calories per capita. Members acquire a lower share of maize calories, but the absolute amount of calories per capita from maize is still 4.4 percent higher than in nonmember households (Table 40).

The diet composition of cooperative members and nonmembers is not significantly different. Members have a slightly larger share of calories from sugar, starchy roots, vegetables, meat products, fats, and other processed foods (Table 40). These differences between averages of members' and nonmembers' consumption appear to be largely determined by the differences in income levels and distribution. As shown in Table 39, per capita calorie consumption of members within the same expenditure quartile as nonmembers is sometimes slightly higher (for example, in the lowest and highest quartiles) and sometimes slightly lower (for example, in the two middle quartiles). More refined approaches are used below to test for the significance of these differences.

The basis for the concept of this analysis of the effects of increased export crop production on food consumption is that the principal relationships between change in prices and levels of income and food consumption are well established. Since real income increased in households that adopted new export crops, the hypothesis is that food consumption levels increased, too. Less clear are hypotheses related to the effects

Table 40—Food availability and composition of food consumption in cooperative member and nonmember households, 1985

Category	Members	Nonmembers
Calorie availability per adult equivalent per day	2,931	2,733
Percentage of total calories		
Maize	53.8	55.3
Other cereals	6.2	6.8
Pulses	8.1	8.3
Sugar	12.1	11.8
Starchy roots, bananas	2.7	2.5
Vegetables, fruits	5.6	5.4
Milk	0.5	0.4
Meat, eggs, fish	6.4	5.8
Fats and oils	1.3	1.0
Other foods and beverages, meals outside home	3.3	2.7
Total (percent)	100.0	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

of income-source changes, control over household income, and the form and frequency of income. (For a review of evidence on this issue, see Braun and Kennedy 1986, 55-59.) Export vegetable production impinges on all of these jointly with its favorable effect on the overall real income. The net effect of export vegetable production on household food consumption may thus be smaller or larger than the "pure" income effect suggests. These factors will be evaluated in the following model, which attempts to explain aggregate household-level food availability in the form of calories (c_i):

$$c_i = f(I_i, I_i^2, S_j, D_n, P_m, M_q), \quad (9)$$

where

I_i = per capita income of household i (total expenditure is used as income proxy),

S_j = a set of j variables describing sources of income (from new cash crops, off-farm women's income),

D_n = a set of n variables describing household size and composition,

P_m = a set of m variables depicting food prices that respective households face, and

M_q = a set of q variables describing the membership and its duration in the cooperative for export vegetable production.

The model is estimated both for the total sample and separately for the lowest 50 percent of income groups among members and nonmembers. The actual specifications of the model along the above-formulated hypothesis and the estimation results are presented in Table 41.

The estimated response of calorie availability to changes in levels of income is highly significant. Additional income increases calorie consumption (LTEXPC), but at decreasing rates at the margin (LTEXPCSQ). The elasticity of calorie consumption with respect to income is 0.306 at the total sample mean. Since the new export crops increased household per capita income, a positive effect for calorie consumption in cooperative member households is to be expected according to these parameter estimates.

Since the food expenditure analysis in the previous section suggested that export crop income is spent less than other income for food at the margin, the extent to which this translates into calorie consumption is tested. It is hypothesized that membership in the cooperative reduced women's off-farm income and increased shares of cash income from new crops, which are controlled by men (see, for example, Tinker 1979).

Most purchased food items in Guatemalan households are actually acquired by women. Maize is the only food that is purchased in a significant amount by men (Table 42). In this environment, women's income levels may have a particularly positive effect on levels of food acquisition over and above total income of the household. This hypothesis, tested by the variable RFNAGINC—share of (off-farm) income earned by women in total income—in Table 41, does not find statistical support. Income earned by women off-farm does not significantly change calorie acquisition after controlling for total income, although it was found earlier in the expenditure analysis that an increased share of female-controlled off-farm income increased the budget share to food beyond the income effect. The explanation for this difference may be that the

Table 41—Availability of calories in households and export vegetable production: regression model

Variable	Total Sample		Lowest Two Quartiles			
	Parameter	t-Value	Cooperative Members		Nonmembers	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
LTEXPC	20,446.410	2.663	3,928.210	1.218	6,289.810	3.794
LTEXPCSQ	-1,328.330	-2.072				
RFNAGINC	-1,685.120	-0.971	-1,096.170	-0.437	-1,675.740	-0.606
RCASH	57.254	0.082	553.030	0.438	173.124	0.194
HHSZ	1,747.343	13.021	1,244.150	5.075	1,510.410	6.629
RCHILD	-6,627.550	-3.106	-4,957.520	-1.088	-4,923.010	-1.230
MPRICE	-82,424.880	-5.774	-46,732.990	-1.821	-54,545.190	-1.648
BPRICE	505.477	1.020	949.183	0.826	1,139.320	1.168
MIEM	-829.710	-1.218				
(Constant)	-47,623.400	-2.060	-6,841.310	-0.394	-18,424.900	-1.417
	R ² = 0.41		R ² = 0.33		R ² = 0.64	
	F = 26.6		F = 4.20		F = 9.60	
	DF = 340		DF = 60		DF = 98	

Notes: Dependent variable: calories available for consumption per day in the household (from purchases and consumed from own production, 1985).

- LTEXPC = log of total expenditures per capita per year in quetzals (as a proxy for permanent income);
- LTEXPCSQ = LTEXPC squared;
- RFNAGINC = ratio of female off-farm income over total income (total expenditure is used as proxy for permanent income in the ratio);
- RCASH = ratio of income from new cash crops over total income (total expenditure is used as proxy for permanent income in the ratio);
- HHSZ = number of persons in the household;
- RCHILD = ratio of number of children under 5 over number of persons in the household;
- MPRICE, BPRICE = price of maize, beef; and
- MIEM = membership in the cooperative (1, else = 0).

Table 42—Purchasers of food items in household transactions

Food Item	Husband	Wife	Other Person
		(percent)	
Milk	8	87	5
Eggs	1	92	7
Pork	2	95	3
Sausage	2	90	8
Maize	24	76	...
Beans	2	93	5

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Data are based on one-month recall.

usual off-farm work in trading and services takes women away from home from morning till sunset even if temporary migration is not involved, and that more expensive time-saving foods may enter the budget of such households. Obviously, generalizations of the relationships between women's income and food acquisition are risky if the interactions with mode of income earning are not taken into account. The issue of the actual value of human time discussed above and the possibly different utility derived by households from on-farm versus off-farm work at equal returns per unit of time is also relevant here.

An increased share of income from new export crops (RCASH) does not have a significant effect on calorie acquisition beyond the income-level effect. The respective parameters of this variable are not statistically significant in any of the three models (Table 41). That is, income from the new export vegetables translates into calorie availability no differently than income in general.

The model for the total sample tests whether membership in the cooperative (MIEM) and the share of income from export crops (RCASH) affect calorie acquisition beyond the absolute income effect. The respective parameter estimate of cooperative membership suggests a marginally significant negative effect on calorie availability (the parameter of MIEM is not statistically significant; see column 1, Table 41). Although this appears as the general picture, the situation seems different at low-income levels, as shown by the separate estimates of the calorie consumption functions for members and nonmembers in the lowest income half of the joint income distribution (Table 41). Nonmembers show a significant positive response in calorie acquisition with rising income but members do not. Calculated at the identical income level at the mean of the joint sample—not at the differing means of the two separate samples, which would distort the picture—cooperative members increase their calorie acquisition by 2.8 percent with 10 percent more income, but nonmembers increase theirs by 4.4 percent. (This income elasticity of calorie acquisition among members is based on a parameter estimate that is statistically not significant—see Table 41.) The households in the area are clearly price-responsive in their calorie acquisition. Understandably, the maize price (MPRICE) is most prominent in this respect, as about 50 percent of calories come from maize.²¹ The estimated (maize) price elasticity of calorie consumption is high; -1.15 among the lowest income half of nonmembers and 0.95 among the members in that income group, which means that a 10 percent increase in the maize price reduces calorie availability by 9.5 percent at the household level. If increased export vegetable production were to shift farm households from net sellers or self-sufficiency to net purchasers, or shift whole village communities in the Western Highlands to net importers, the related price effect could have a significant effect on calorie consumption.

In the final assessment, the effects of increased export crop production on food acquisition are on average positive in terms of calorie availability to the households, supporting further the conclusion drawn from the agricultural production and income assessments that household-level food security seems to have improved. Yet the change in the source of income-earning reduces the positive gross-income effect for calorie acquisition from an expected increase of 7.2 percent to an overall net effect of 1.9 percent in a typical farm household that joined the cooperative (based on model in column 1, Table 41). The following section traces these effects to the nutritional status of children.

²¹ Price variability in the cross-sectional sample results from local price differences and the fact that households face in varying degrees a c.i.f. price if they are purchasing or an f.o.b. price if they are selling. To households that are only consuming their own-produced maize, the local f.o.b. price was assigned to represent the shadow price of maize consumption.

Effects on Nutrition

The nutrition problem in the Western Highlands is a syndrome that stems from poverty. The health and sanitation environment along with the ability to acquire food—be it from own production or market—and employment, especially of mothers, are important interrelated factors that determine the nutritional performance of children (Balderston et al. 1981). The new export vegetable production scheme directly or indirectly impinges on all of these variables.

Patterns of Malnutrition in the Region and Sample Population

In a number of social indicators, cooperative member households appear to have a better standard of living than nonmembers. Many of these indicators may be directly or indirectly linked to increased income of members, but other indicators may reflect their desire and ability to change their living standards as compared with others in the communities. In general, members have higher education levels, better housing and water supply conditions, and higher-quality health services (clinics). Basic health services, such as vaccination, are used similarly by the two groups. Although they are generally less poor, the percentage of members obtaining food aid tends to be higher than among nonmembers (see indicators, Table 43).

As found in the above analyses, both real household income and food from own production increased due to export vegetables. Women's on-farm employment increased, leading to less off-farm work. Employment in the six communities also increased due to export cropping; this should be beneficial to the local landless and smallest farmers, who depend more on off-farm work. However, the country went through a period of general economic decline in the mid-1980s that adversely affected economic opportunities of the poor. Thus it is an open question whether the nutritional situation in the six communities generally improved. This question will be evaluated using nutritional status indicators of children—weight-for-age, height-for-age, and weight-for-

Table 43—Selected social indicators for cooperative members and nonmembers

Indicator	Members	Nonmembers
	(average)	
Household size (persons)	6.7	6.4
Literate heads of household (percent)	61.7	55.4
Electricity in the house (percent)	60.3	47.7
Housing conditions		
Houses with mud floor (percent)	41.7	56.5
Houses with corrugated iron (percent)	69.7	49.8
Own water tap or own well (percent)	79.6	61.9
Use of health services (percent)		
At clinics	45.6	33.4
At pharmacy or other services	50.1	60.6
Vaccination of children under 5 years (percent)		
Measles	68.6	65.1
BCG	70.8	67.1
DPT (3 or 4 doses)	50.0	46.6
Polio (3 or 4 doses)	48.8	45.3
Food aid received in		
1983 (percent of households)	53.2	45.8
1985 (percent of households)	45.0	42.8

Source: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

height. In this analysis, the respective indicators are normalized for age differences by expressing them in terms of their deviation from the age-specific standards over the standard deviation (Z-scores).²²

The general nutritional situation in the study area, as represented by children in households not participating in the cooperative, is not very different from other parts of the highlands despite the accessibility of the survey villages to Guatemala City and to infrastructure (Table 44). Also, prevalence rates of malnutrition in these communities (especially height-for-age) are at similar levels to, or even higher than, the rates found in more remote parts of the Western Highlands (Table 45).

Comparing the Guatemalan data with comparable data from Africa, significant differences are found. For instance, average Z-scores for growth retardation of about -1.4 were found in a comparable survey in The Gambia (von Braun, Puetz, and Webb 1989). However, a straight comparison of average Z-scores of anthropometric indicators across populations may not be fully justified because of ethnic differences between populations. Therefore, the focus is mainly on relative changes rather than absolute levels of anthropometric status as a nutritional indicator in this analysis.

A comparison of the 1983 and 1985 prevalence rates does not indicate a general improvement in nutritional status (Table 45). However, this tendency should not be generalized to local developments. During these years, Guatemala was going through a severe economic crisis, which may be the reason for this general pattern of development. Desired information on change over time in anthropometric indicators from other Guatemalan locations in the early 1980s is not available. Comparison of cooperative members with nonmembers shows that children of members tend to be better off in terms of weight-for-age and height-for-age and about the same in terms of weight-for-height.

Table 46 presents an analysis of the prevalence of wasting and stunting among the children of families who are members versus nonmembers. Two cutoff points are used for both the weight-for-height and height-for-age standards. The commonly used cutoff point to classify wasting is children below 80 percent weight-for-height, and for stunting, below 90 percent height-for-age standards. Only children 6-60 months of age are included. By the above standards, 66.7 percent of children of members and 75.7

Table 44—Nutritional status of children under 60 months in the study area and other locations in Guatemala

Area	Weight-for-Age	Height-for-Age	Weight-for-Height
		(average Z-scores)	
Study area, 1985 ^a	-1.89	-3.27	0.11
A study area in four villages in Patulul area, 1984	-1.98	-3.26	0.00
A study area of coffee plantations, 1984	-1.65	-2.61	-0.05

Sources: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985; and data from Victor Valverde, Hernán Delgado, Rafael Flores, and Ricardo Sibrián, "Minimum Wage Law and Nutritional Status in Guatemala," Institute of Nutrition of Central America and Panama, Guatemala City, 1985, (mimeographed).

^a Children aged 6-60 months of the nonmembers of the cooperative.

²² The National Center for Health Statistics standards were used for Z-scores. Z-scores are standard deviation scores. For any value X_i , the Z-score is $(X_i - \bar{X})/S$, where $\bar{X}$ is the median and S is the standard deviation of the reference population. A negative (positive) Z-score means the specific value X_i is "Z" standard deviations below (above) the median of the reference population.

Table 45—Prevalence of malnutrition in the Western Highlands of Guatemala

Area	Children Below -2 Z-Scores		
	Weight-for-Age	Height-for-Age	Weight-for-Height
		(percent)	
Study area, 1983 ^a	43.2	82.1	1.7
Study area, 1985 ^a	42.4	89.2	1.3
Western Highlands (north)	36.8	67.6	1.7
1983 ^b	36.8	67.6	1.7
1987 ^c	58.3	66.2	8.2
1987 ^d	51.7	81.8	4.2

Sources: Based on data from USPADA/INCAP/UCPRODA, *Resultados del Análisis de las Encuestas de Base Agroeconómica, Dieta y Estado de Nutrición Infantil*, Project MAGA-AID 520-T-034/0255, 1983 (Guatemala City: INCAP, 1986); Cooperación Guatemalteca-Alemana Alimentos, *Informe Final, Baseline Survey, Análisis del Grupo Meta (Población Rural de los Departamentos El Quiché-Sur y Totonicapán)*, vol. 2 (Guatemala City: COOGAT, 1987); and Institute of Nutrition of Central America and Panama, *Informe de los Resultados de las Encuestas de Consumo de Alimentos y Estado Nutricional*, Project MAGA-AID 520-T-034/0255, 1987 (Guatemala City: INCAP, 1988).

^a Children aged 6-60 months of the nonmembers of the cooperative.

^b Six departments: Huehuetenango, Quetzaltenango, San Marcos, Totonicapán, El Quiché, and Sololá; children aged 0-60 month(s).

^c Two departments: Totonicapán and El Quiché; children aged 0-71 month(s).

^d Six departments as in note (b); children aged 12-60 months.

percent of children of nonmembers were stunted in 1985. This reflects an increase in both groups, although somewhat higher in the nonmember group. Severe stunting (below 80 percent) hardly prevails among children of members (0.6 percent) but affects children of nonmembers (5.8 percent). Severe wasting, which represents an indicator of short-term nutrition problems, is practically nonexistent in both groups. In 1985, 0.6 percent of children of members and 1.0 percent of children of nonmembers were affected.

Table 46—Prevalence of malnutrition among children of cooperative members and nonmembers, aged 6-60 months, 1983 and 1985

Year	Members ^a		Nonmembers ^a	
	Weight-for-Height	Height-for-Age	Weight-for-Height	Height-for-Age
	(percent of children below 90 percent of reference standard) ^b			
		(stunted)		(stunted)
1983	15.1	59.3	10.2	65.1
1985	6.8	66.7	7.8	75.7
	(percent of children below 80 percent of reference standard) ^b			
	(wasted)		(wasted)	
1983	2.3	0.6	0.9	4.2
1985	0.6	0.6	1.0	5.8

Source: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Number of children: 1983 = 172 members, 215 nonmembers; 1985 = 177 members, 206 nonmembers.

^b The standards used are the National Center for Health Services standards.

In both groups, children who have been moderately underweight substantially improved, relatively more among cooperative members. Between 1983 and 1985, the percentage of children below 90 percent of the weight-for-height standard decreased from 15.1 to 6.8 percent among children of members, and from 10.2 to 7.8 percent among children of nonmembers.

Income and Nutritional Improvement

The straightforward comparisons of mean values and prevalence rates of malnutrition provide limited insights, since the earlier analysis showed that members of the cooperative have higher incomes than nonmembers. The sample is therefore broken into three income classes, using expenditure per capita as an income proxy. For children 6-120 months of age, there is a generally positive but weak relationship between income and nutritional status (Table 47). While children in the middle and highest terciles showed a slight improvement in their weight-for-age Z-scores, children from households in the lowest group appear to have worsened between the two rounds. The prevalence of stunting (height-for-age) increased among children from households in the bottom and middle terciles, while it decreased among the highest income group. The higher prevalence of stunting may be related to the worsening of the general socioeconomic conditions during the first half of the 1980s, when real per capita GDP decreased by 20.5 percent (1981-85) in Guatemala.

Because of increases in real income, available food from own production, and women's on-farm employment, as well as overall employment in the six communities, which is beneficial to the landless and the smallest farmers, it is hypothesized that the nutritional situation improved for both members and nonmembers of the cooperative. The following model is a reduced form of income-nutrition relationships. At higher

Table 47—Income levels and prevalence of malnutrition among children of cooperative members and nonmembers, 1983 and 1985

Measure	Year	Number in Sample	Children Below -2 Z-Scores		
			Lowest Income Tercile	Middle Income Tercile	Highest Income Tercile
(percent of children 6-120 months)					
Weight-for-age	1983	755	41.6	38.9	36.8
	1985	824	43.0	36.5	32.2
Height-for-age	1983	755	77.4	75.0	77.7
	1985	824	83.4	87.4	74.4
Weight-for-height	1983	755	1.9	0.8	2.1
	1985	824	1.9	0.7	0.8
(percent of children 6-60 months)					
Weight-for-age	1983	406	46.2	38.0	39.7
	1985	394	48.3	38.2	34.1
Height-for-age	1983	406	78.7	78.5	83.6
	1985	394	84.8	95.8	81.1
Weight-for-height	1983	406	2.4	1.7	0.9
	1985	394	1.7	1.4	0.8

Source: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Income levels refer to expenditures of respective year in per capita terms as income proxy (excluding value of own-produced food consumed, which was not collected in 1983 survey).

income levels, reduced marginal effects of increased income for nutritional improvement are expected. It is further hypothesized that an increased share of male nonagricultural income or export crops has a negative effect on child welfare, holding household income constant. If a disproportional share of income is spent on luxuries, children's nutritional status would deteriorate at a given income level. On the other hand, it is hypothesized that an increased share of female-controlled income leads to increased child welfare-related spending and nutritional improvement. Subsistence food income is included in the total household income variable in this reduced-form model, which has the following formula:

$$S_{ij} = f(\text{DEM}_{ij}, \text{INCOME}_j, \text{INCOMP}_j), \quad (10)$$

where

S_{ij} = nutritional status of child (i) in household (j) in 1985;

DEM_{ij} = demographic variables of child (sex, age in months—level and squared—birth order);

INCOME_j = household (j) income per capita per year (and the respective squared term); and

INCOMP_j = composition and sources of income (shares from new export crops, male- or female-earned nonagricultural income).

The results indicate that the level of income is highly significant for the weight-for-age, height-for-age, and weight-for-height indicators (Table 48). At higher levels of

Table 48—Effects of income and income source and composition on nutritional status: multivariate analysis for children aged 6-120 months

Explanatory Variable	Weight-for-Age Z-Scores		Height-for-Age Z-Scores		Weight-for-Height Z-Scores	
	Estimated Parameter	t-Value	Estimated Parameter	t-Value	Estimated Parameter	t-Value
Age in months	-3.489E-03	-0.85	-0.0156	-3.03	-9.485E-03	-2.28
Age squared	3.497E-05	1.14	1.397E-04	3.64	1.053E-04	3.39
Birth order ^a	1.706E-04	0.01	-0.0240	-1.37	0.0220	1.55
Sex (male = 1, female = 2)	7.083E-03	0.12	0.0379	0.52	-0.0562	-0.96
Duration of breastfeeding ^b	9.663E-05	2.03	1.894E-04	3.17	-3.063E-05	-0.63
Income per capita ^c	8.231E-04	3.20	7.807E-04	2.41	5.162E-04	1.98
Income squared ^c	-3.930E-07	-2.74	-3.489E-07	-1.93	-2.625E-07	-1.80
Share of male nonagricultural income	0.1613	2.00	0.3291	3.24	-0.0531	-0.67
Share of female nonagricultural income	0.4953	2.20	0.4895	1.73	0.3140	1.37
Share of income from export crops	0.1569	1.88	0.1958	1.81	0.0640	0.73
Constant	-2.1165	-12.89	-3.110	-15.08	0.0549	0.33
R ²	0.032	...	0.073	...	0.028	...
F-value	3.590	...	7.280	...	3.290	...
Degrees of freedom	785	...	785	...	785	...

^a First-born child = 1, second = 2, and so forth.

^b Variable only for children above 24 months of age (else = 0).

^c Expenditure per capita per year is used as a proxy for income.

income, the marginal effect is reduced as hypothesized, indicated by the negative sign for the squared income term. Thus the effect of marginal income on nutrition is greater in poor households than the sample means indicate. At sample mean, a 10 percent increase in income increases the weight-for-age Z-score by 1.5 percent, the height-for-age Z-score by 0.9 percent, and the weight-for-height Z-score by 9.7 percent. The high income elasticity of short-term nutritional improvement (weight-for-height) suggests that even marginal income growth among the poor leads to significant short-term weight gains of children. It thus can be inferred that increased real income due to the export crops has a particularly significant effect in this respect. To reduce stunting substantially, however, would require a major increase in income.

Higher shares of either male or female off-farm nonagricultural income improve the nutritional status of children. Although this is contrary to the study hypothesis concerning male-controlled income, the respective parameter values indicate different levels of impact. In the weight-for-age model, women's income always had a greater impact on nutritional status than men's income. In the height-for-age model, which depicts long-term effects, the differential effect between male- and female-controlled income is less pronounced; for short-term nutritional status (weight-for-height), income control within the household does not appear to be an issue (the parameters are not statistically significant).

A higher share of income from the new export crops has a low positive effect on nutrition after controlling for income in the weight-for-age and height-for-age models but is not significant in the weight-for-height model. The hypothesis that income from new cash crops, which is largely male-controlled, would be disproportionately used for nonfood and luxury items that would adversely affect nutrition of children in the household does not find support in this analysis.

Social Programs

The commercialization process studied in this case is inseparable from the Cuatro Pinos cooperative scheme. The cooperative has developed and implemented three types of social programs: productive, educational, and medical. These programs may improve the health status of children and have a long-term effect on nutritional improvement beyond the income-consumption effect of the new export crops.

Productive programs include a rabbit project that was started in March 1986 for women. This project consists of providing credit for acquisition of a rabbit pen and three rabbits—credit that must be repaid in one year. Furthermore, participants are trained in rabbit growing, maintenance, and slaughtering techniques. As of April 1987, 105 women had participated in the project. It is estimated that 50 percent of the rabbit meat production is for own consumption, and the remainder is sold to supermarkets in Guatemala City.

By statute, 10 percent of the cooperative's profits are earmarked for its educational fund. The first program (initiated in Santiago in 1978) was an adult education program for members and nonmembers, with primary education and literacy classes. In 1983 the program was expanded to three communities and was taught by three teachers directly employed by the cooperative. In 1986, 132 adults (36 nonmembers) finished the primary education subprogram and 66 (12 nonmembers) finished the literacy subprogram.

In 1980, with funds from the Swiss Group, a nongovernmental development organization, several children began to receive study scholarships. The scholarship program was formally organized in 1985, and scholarships are provided for secondary education and vocational training and normally cover tuition and books. The education committee

of the cooperative reviews and approves scholarship applications. In 1987, 47 scholarship applications were approved.

An institution providing secondary education has been established in Santiago and receives financial assistance from the cooperative, thus benefiting some members indirectly. Additional educational programs for schoolchildren were started in 1985 in production techniques related to vegetables and aspects of cooperativism, and in 1986 cooperative education courses were organized for members, their spouses, schoolchildren, and cooperative officials. Technical training in such fields as administration and accounting was initiated in 1987 for personnel of the cooperative.

In 1984 the cooperative organized a food and nutrition program for spouses of members. As of mid-1987, 225 women have participated in this program, whose contents center on different ways of preparing vegetables (particularly broccoli, snow peas, and cauliflower) and their nutritive values, in order to stimulate more own consumption of these foods. The program is conducted by two home extension workers who are employees of the cooperative and were partially trained by INCAP.

The medical services program consists of several subprograms: maternal-infant, pre- and post-natal care, outpatient consultations, and deworming. The program is currently carried out in all communities from which the cooperative draws members. The staff consists of a full-time doctor (as of August 1986) who is an employee of the cooperative. The doctor spends four afternoons a week in the health clinic in Santiago and divides the remainder of the time among the other communities. This is in addition to a full-time health promoter who, among other things, prescribes medicines. From 1982 to August 1986, a medical doctor provided services two mornings a week in Santiago and Pacul. In January 1987 the cooperative established a pharmacy in Santiago that also supplies medicines to the other communities.

Food Consumption and Health-Based Model of Nutritional Improvement

To assess the effects of increased commercialization on the nutritional status of children, it is hypothesized that the related income effects—identified in the reduced-form model above—can be traced to nutrition through increased food consumption and improved health and sanitary conditions. Such further separation of the elements of the growth and development process traced to nutritional effects is desirable for policy and program design.

The model, unlike the reduced-form, income-based model in the previous section, is a cohort-specific analysis of determinants of change in nutritional status. The model for the identical children aged 6-60 months in 1983 and 30-84 months in 1985 has the following form:

$$dS_{ij}^{(1983-1985)} = f(DEM_{ij}, CAL_{ij}, BRE_{ij}, SAN_{ij}, EDU_{ij}, PER_{ij}, S_{ij}^{(1983)}), \quad (11)$$

where

$$dS_{ij} = S_{ij}^{(1985)} - S_{ij}^{(1983)};$$

$$DEM_{ij} = \text{demographic variables of child (sex, age in months—level and squared—birth order);}$$

- CAL_i = household-level calorie consumption per adult equivalent (level and squared);
 BRE_{ij} = breastfeeding duration (children over 24 months);
 SAN_i = sanitary environment (latrine);
 EDU_i = education of head of household (years of schooling);
 PER_i = years of cooperative membership; and
 S_{ij} = nutritional status of child $_{(ij)}$ in household $_{(i)}$ in 1985 (weight- or height-for-age, or weight-for-height Z-scores).

In this model of the determinants of change in nutritional status, household calorie availability is included as a proxy variable for household food consumption. Household food availability may not be a satisfactory indicator of child food consumption. The hypothesis is that children capture a share of incremental household calories. Additional indicators related specifically to breastfeeding duration are also introduced.

Poor latrine facility is used as a proxy for sanitation environment. It is further hypothesized that households with better education have the ability to make better use of available resources to improve the health and nutrition of their children. Finally, the duration of membership in the cooperative is evaluated for its effect, beyond the income-consumption effect, on children's health and nutritional status. Beneficial effects from cooperative membership may come from participation in the social programs, such as literacy classes, food and nutrition education of women, and improved information exchange among communities. Adverse effects might result from changes in income control not captured fully by the food consumption variables and women's time constraints for child-nurturing activities.

Inclusions of an individual child's nutritional status indicator (1983) before the period during which change is measured (1983-85) take account of individual characteristics. This increases the overall explanatory power of the models as compared with the purely cross-sectional, income-based models. The lower the Z-score at the outset (1983), the greater the reduction in weight deficiencies during the two years of observation.

For instance, children who were underweight at -2 Z-scores in 1983 tended to catch up by one Z-score over the period (-0.5004×-2 , see Table 49). This points out that a high proportion of malnutrition—reflected in weight deficiency—is of an episodic nature. These serial episodes of weight loss then create the long-term nutritional problem reflected in growth deficiency (see, for example, Balderston et al. 1981). Although significantly increasing, too, catch-up growth from a stunted position at the outset occurs much less often than catching up on weight. It should be noted that age of the child is controlled for in this analysis and seasonality is eliminated, as the sample surveys were done at the same time of the two years.

Other results of the regression models presented in Table 49 relate to the effects of food consumption: household-level calorie availability does have a strong positive effect—though decreasing at the margin—on the more short-term indicator of nutritional status (weight-for-height). Current calorie consumption would be an unsatisfactory indicator for the food availability history to which the children were exposed. For this reason, in the long-term model of nutritional status (height-for-age), current calorie

Table 49—Determinants of change in nutritional status and the role of export crop production: multivariate analyses for cohort of children

Explanatory Variable	Change in Weight-for-Age Z-Scores		Change in Height-for-Age Z-Scores		Change in Weight-for-Height Z-Scores	
	Estimated Parameter	t-Value	Estimated Parameter	t-Value	Estimated Parameter	t-Value
Age in months	0.0296	1.60	0.0140	0.74	0.0366	1.79
Age in months squared	-2.548E-04	-1.62	-4.248E-05	-0.27	-3.132E-04	-1.81
Birth order ^a	0.0482	2.72	0.0144	0.82	0.0689	3.54
Sex (male = 1, female = 2)	-0.0226	-0.32	-0.1009	-1.39	0.04133	0.52
Calories per day per adult equivalent, 1985	5.249E-05	0.73	...	...	2.2029E-04	2.78
Calories squared	-5.586E-09	-0.69	...	...	-2.491E-08	-2.76
Breastfeeding ^c	0.2662	1.64	0.1351	0.82	0.3169	1.77
Unsuitable latrine (= 1, else = 0)	-1.212	-0.68	-0.3459	-1.91	0.0556	0.28
Education of household head (years in school)	0.0261	1.28	0.0188	0.92	0.0217	0.97
Z-score of weight-for-age, 1983	-0.5004	-13.48	...	...	...	...
Z-score of height-for-age, 1983	...	...	-0.2672	-7.90	...	...
Z-score of weight-for-height, 1983	...	...	...	...	-0.6984	-17.34
Duration of membership in cooperative (years)	7.694E-03	3.37	0.01237	5.36	1.774E-03	0.70
Constant	-2.278	-3.88	-1.784	-3.10	-1.914	-2.95
R ²	0.360	...	0.229	...	0.469	...
F-value	20.400	...	13.500	...	31.500	...
Degrees of freedom	369	...	371	...	369	...

Note: These analyses are based on a cohort of children who were aged 6-60 months in 1983 and 30-84 months in 1985.

^a First-born child = 1, second = 2, and so forth.

^b The variable is not included in this model because it is not assumed to have an effect on the long-term measure of nutritional status.

^c If child was breastfed = 1 (else = 0).

availability was not included as a variable. To the extent that the new export vegetables increased income, and thus increased household food availability, these results show that the nutritional status of children is likely to be improved, at least in the short run.

POLICY CONCLUSIONS AND GENERALIZATIONS

This study of export crop production in smallholder agriculture is based on experience with a scheme that relies for success on particular conditions described earlier in the report. Clearly the Cuatro Pinos cooperative is an exceptional case of agricultural and rural development and is not typical in Guatemala. However, it is precisely because the cooperative stands out favorably in an environment of numerous failures of agricultural modernization with farmers' participation in Central America that it is possible to arrive at important policy conclusions.

Mellor and Desai (1985, 209) stress that disparities in the distribution of assets and power, which are often based on the social as well as the economic structure, must be recognized. "The need for radical institutional changes may have been overstated in recent years vis-à-vis technological change in agriculture but the necessity for such change must always be examined." Also, their emphasis that "state-sponsored dualism must be guarded against" and that "a full attack must be made on all discriminatory practices that restrain the poor" is of great relevance for this case study.

In studying the effects of increased commercialization of traditional smallholder agriculture in Guatemala, the broader context of the "agrarian crisis" in Latin America, which provides the political and economic environment of this study, should be kept in mind. As de Janvry (1981, 3) puts it, the agrarian crisis in Latin America is characterized by sharply uneven development among farms, crops, and regions, and by massive rural poverty and political tensions. In contrast to the poverty issue in much of Africa, poverty is not a separate phenomenon but is to be seen in terms of its functionality (de Janvry 1981, 149). Low productivity in the traditional sector, unemployment, and regressive income distribution patterns may be identified as direct causes of poverty but are, at the same time, a function of the political-economic systems. As a consequence, de Janvry (1981, 150) points out, policy recommendations regarding poverty run the risk of assuming a reality separate from the functioning of the economic system when they are only directed by idealistic and humanitarian concerns.

Clearly, political and economic structures should be kept in focus when policy conclusions are derived from the case studied here. When the implications of the new export crop production are evaluated here in the context of the existing political-economic system, this is not intended to imply that the effects of this type of export crop scheme are independent of the political system. In a drastic way, this was made clear by the violent repressions that peasant organizations, such as cooperatives, suffered in some parts of Central America in the early 1980s (Williams 1986).

Using Adelman's (1975) term, Guatemala may be a case for "redistribution before growth." Taking a pragmatic evolutionary approach to the problem leads to the derivation of criteria for rural change that work in a desirable direction. Two issues are essential in this respect. The first is the identification of policies that make use of the opportunities for agricultural trade to sustain, not oppose, the relation between growth and distribution. The second is the question classified by de Janvry (1981, 265) as probably the most important one in this context, "whether growth itself is articulating." Does growth through the creation of employment, and hence domestic demand for

wage goods, lead to gradual changes in the production structure that result in "social articulation" of the poor, that is, expressed demand for services, infrastructure, education, and participation in decisionmaking and priority-setting in the development process?

Concerning the first issue—trade opportunities and distribution—the production of export vegetables has worked in the right direction in this study. Some peculiarities of the new crops and the conditions at the location have produced this outcome. Because of their diseconomies of scale in production, nontraditional crops ended up on the smallest farms in the poorest area of the country, creating employment for the small farmers and local landless, substantially increasing real income, and favorably affecting food security and consumption. The favorable effect of the nontraditional crops for small farmers largely depends upon the crops' characteristics, which are very different from those of such traditional export products as cotton, coffee, and beef. These products have apparently positive returns to scale in production and are produced more efficiently on the other end of the dual spectrum of Guatemala's agriculture—the large-scale farm enterprises.

As for the second issue—social articulation—the study finds that institutional changes combined with the expansion of export crop production in a cooperative scheme are forces leading toward social articulation. Noteworthy are the strengthening of cooperation among farmers, increased interaction between village communities, development of local trading and entrepreneurship due to the new crops, and related buildup of economic power in the rural areas by the small-farmer-based economic growth. An earlier discussion (Chapter 4) showed that development assistance can and actually has played a catalytic role in this process. The economic costs of terminating this process are now higher, especially in light of the country's severe foreign exchange problem, which nontraditional export vegetable production plays an important role in alleviating.

No general automation between growth and social articulation of the poor that could lead to development can be postulated based on this study. The study demonstrates the existence of niches in the system that provide this potential and also highlights the specific conditions under which it may work. Central to these conditions are the diseconomies to scale in producing the export vegetables and the ecological conditions in the Western Highlands along with the labor market situation.

The sustainability and expansion potentials of the program depend on the functioning of the marketing channels, domestically and internationally, for both inputs and outputs. The implicit taxation of small farmers through overvalued exchange rates for outputs is a matter of concern. The riskiness of the new crops due to potential disturbances in the marketing chain needs to be a matter of constant attention.

For maximum gains from specialization, policies that ensure efficiently functioning food, labor, and financial markets are the first-best solution. Market imperfections are the worst enemies of sustainable market integration of the subsistence farm sector. As long as market failures cannot be excluded and small farmers' perception of their potential occurrence remains due to past experience (and this may change only slowly), second-best options for policy must be considered. Therefore, the deep-rooted desire for food security achieved by high levels of self-sufficiency at the household level in the Western Highlands can best be accommodated by rapid technological improvements in the traditional subsistence crops—maize and beans—along with expansion of the new export vegetables. This is also a condition for adoption of the new crops and, as observed in this study, small farmers manage to achieve complementarity between growth in the subsistence crops and the new crops.

Accelerated growth in food production alone would have little effect on the general poverty situation in the Western Highlands. Single-minded focus on nontraditional export crops would be risky for small farmers' food security and would be constrained by the adoption problem if food crops did not move jointly.

To cope with production risk and to finance the adoption of the input-intensive new crops, a functioning rural capital market is essential. Rural credit and banking schemes that open up outlets for rural savings are essential for long-term growth. Otherwise, savings find their way into the form of assets—that is, land—with obvious efficiency losses to the initiated development and potential adverse distributional effects at the micro level.

Modest, though statistically highly significant, improvements in nutrition via the favorable income and consumption effects of the program may be expected, as shown by the analysis. This suggests that rapid employment and income growth will make a difference that can be translated into nutritional improvement at the low levels of poverty. The research further suggests that the income-growth effect needs to be supported by appropriate health- and nutrition-oriented social infrastructure. This requires sustained government commitment and community-based actions rather than short-term charity. Development assistance can play an important role if the objective is seen as building up the human capital of the poor.

Given the important role of nonagricultural rural employment in the Western Highlands, the productivity of the growing landless population group depends upon improved human capital, with education and training playing crucial roles. Increasing the human capital stock is also a prerequisite for agricultural productivity to grow in a sustainable way. It is hardly by chance that the early leadership of the export crop cooperative—which the study mainly found to be a success story in the difficult political and economic environment of Guatemala—emerged from intensive primary school courses provided by a local project.

APPENDIX: PROGRAMMING MODEL

Model 1: Precooperative situation

	1	2	3	4	5	6	7	8	9	10	11
	MPRD	BPRD	VPRD	MSAL	BSAL	VSAL	FPUR	SPUR	FL13	FLA6	FL712
	ha 1	ha 1	ha 1	ha 1	ha 1	ha 1	kg 1	kg 1	dy 1	dy 1	dy 1
NET REVENUES											
1 LAND	-5,000	1,000	1,000	1,000	-	-	-	-	-	-	-
2 MYLD	-1500,000	-	-	-	-	-	-	-	-	-	-
3 BYLD	0,000	-600,000	-	-	-	-	-	-	-	-	-
4 YILD	0,000	-	-	-	1,000	-	-	-	-	-	-
5 FERT	0,000	-	-12760,000	-	-	1,000	-	-	-	-	-
6 SPFR	0,000	182,000	494,000	-	-	-	-1,000	-	-	-	-
7 LA13	0,000	31,000	15,000	-	-	-	-	-	-	-	-
8 LAH6	0,000	74,000	43,000	-	-	-	-	-	-	-	-
9 LA712	0,000	45,000	175,000	-	-	-	-	-	-	-	-
10 FX13	0,000	13,000	279,000	-	-	-	-	-	-	-	-
11 FX46	105,000	-	-	-	-	-	-	-	-	-	-
12 FX712	105,000	-	-	-	-	-	-	-	-	-	-
13 CREDIT	210,000	57,000	128,000	-	-	-	0,340	4,500	1,000	1,000	-1,000
14 CRMAX	0,000	-	-	-	-	-	-	-	-	-	-
15 STAPL	1563,000	600,000	-	-1,000	-1,000	-	-	-	-	-	-
16 ROTAT	0,000	1,000	-1,500	-	-	-	-	-	-	-	-
1 LAND	-	-	-	-	-	-	-	-	-	-	-
2 MYLD	-	-	-	-	-	-	-	-	-	-	-
3 BYLD	-	-	-	-	-	-	-	-	-	-	-
4 YILD	-	-	-	-	-	-	-	-	-	-	-
5 FERT	-	-	-	-	-	-	-	-	-	-	-
6 SPFR	-	-	-	-	-	-	-	-	-	-	-
7 LA13	-	-	-	-	-	-	-	-	-	-	-
8 LAH6	-1,000	-	-	-	-	-	-	-	-	-	-
9 LA712	-	-	-1,000	-	-	-	-	-	-	-	-
10 FX13	-	-	-	-	-	-	-	-	-	-	-
11 FX46	-	-	-	-	1,000	-	-	-	-	-	-
12 FX712	-	-	-	-	-	-	-	-	-	-	-
13 CREDIT	2,600	2,600	2,600	-	-	1,400	-1,000	-	-	-	-
14 CRMAX	-	-	-	-	-	-	-	-	-	-	-
15 STAPL	-	-	-	-	-	-	-1,000	-	-	-	-
16 ROTAT	-	-	-	-	-	-	1,000	-	-	-	-

Model 2: Postcooperative, without improved productivity in subsistence crops

[illegible]

Model 3: Postcooperative, with improved productivity in subsistence crops

	NET REVENUES	1 MPRD ha 1	2 SPRD ha 1	3 VPRD ha 1	4 MSAL kg 1	5 BSAL kg 1	6 VSAL kg 1	7 FPU9 kg 1	8 SPUR kg 1	9 FL13 dy 1	10 FL46 dy 1	11 FL712 dy 1
1 LAND	0.750 >	1.000	1.000	1.000	0.210	0.170	0.120	-0.340	-4.500	0.000	0.000	0.000
2 MYLD	0.000 >	-2100.000			1.000							
3 BYLD	0.000 >		-1171.000			1.000						
4 SYLD	0.000 >											
5 VYLD	0.000 >			-12760.000			1.000					
6 FERT	0.000 >	287.000	298.000	694.000				-1.000				
7 SPRT	0.000 >			15.000								
8 LA13	0.000 >	31.000	83.000	43.000								
9 LA46	0.000 >	52.000	57.000	175.000								
10 LA712	0.000 >	40.000	15.000	229.000								
11 FX13	105.000 >											
12 FX46	105.000 >											
13 FX712	210.000 >											
14 CREDIT	0.000 >	5.000	57.000	128.000				0.340	4.500			
15 CRMAX	1583.000 >											
16 STAPL	736.000 <	2100.000	1171.000		-1.000	-1.000						
17 ROTAT	0.000 <	1.000		-1.500								
1 LAND												
2 MYLD												
3 BYLD												
4 SYLD												
5 VYLD												
6 FERT												
7 SPRT												
8 LA13												
9 LA46												
10 LA712												
11 FX13												
12 FX46												
13 FX712												
14 CREDIT												
15 CRMAX												
16 STAPL												
17 ROTAT												

Notes: 1) The opportunity cost of land is computed on the basis of fixed land supply. Land rental is not allowed for in the model. The model is simply built for the "average" farm as described by the sample survey data. A refined approach would certainly entail modelling the farm interactions in the study area between coop and noncoop farmers and the related land and labor market effects.

2) The programming model was solved using the following package: Mve College micro-linear programming package, version 4.0, May 1985, developed by J. P. G. Webster, B. J. George, and P. A. Kentish.

Variables in the Programming Model

<u>Activities</u>		<u>Constraints</u>	
MPRD	= production of maize	LAND	= farm size
BPRD	= production of beans	MYLD	= yield of maize
VPRD	= production of vegetables (traditional)	BYLD	= yield of beans
SPRD	= production of snowpeas	SYLD	= yield of snowpeas
MSAL	= sales of maize	VYLD	= yield of vegetables (traditional)
BSAL	= sales of beans	FERT	= fertilizer use required
VSAL	= sales of vegetables (traditional)	SPRY	= spraying material use required
SSAL	= sales of snowpeas	LA13	= labor required in January-March
FPUR	= purchase of fertilizer	LA46	= labor required in April-June
SPUR	= purchase of chemicals for spraying	LA712	= labor required in July-December
FL13	= use of family labor on farm in January-March	FX13	= family labor available in January-March
FL46	= use of family labor on farm in April-June	FX46	= family labor available in April-June
FL712	= use of family labor on farm in July-December	FX712	= family labor available in July-December
ML13	= hiring in of labor in January-March	CREDIT	= financing requirement
ML46	= hiring in of labor in April-June	CRMAX	= collateral upper limit
ML712	= hiring in of labor in July-December	STAPL	= staple food for consumption from own production desired
OF13	= off-farm work of family labor in January-March	ROTAT	= rotational constraints
OF46	= off-farm work of family labor in April-June		
OF712	= off-farm work of family labor in July-December		
FIN	= financing input acquisition and hired labor		

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FOOD PRODUCTION IN A LAND-SURPLUS, LABOR-SCARCE ECONOMY: THE ZAIRIAN BASIN

Tshikala B. Tshibaka

June 1989

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Tshikala B. Tshibaka

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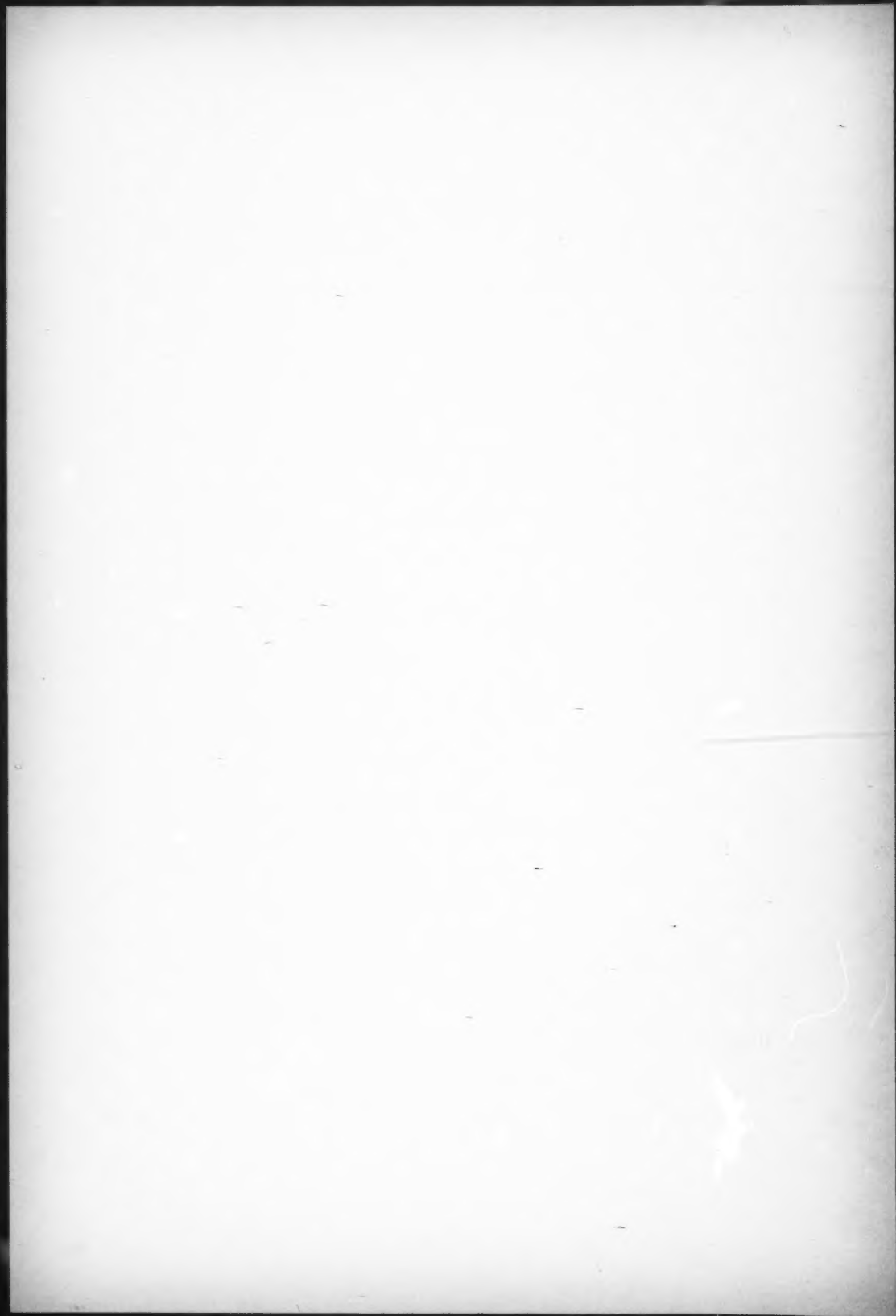
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FOREWORD

Once a net food exporter, Sub-Saharan Africa is now the only major area of the world where the per capita food supply has been declining for the last two decades. Despite massive food imports and aid, the deterioration of the food sector, coupled with rapid population growth, has caused many Africans to face food shortages and other hardships.

The agricultural policies followed in many parts of Sub-Saharan Africa have played an important role in moving the region from a net food exporter to a net food importer. This report on food production in Zaire is the first in a series of studies being undertaken by the Food Production Policy Program at IFPRI on factors impeding food production in the smallholder sector of the region.

In this research report, Tshikala B. Tshibaka describes the state of the small-farm sector in the Zairian Basin and identifies different constraints affecting productivity and hence the volume of food output this sector produces. This study not only adds to our knowledge of the Zairian economy, but it also constitutes a useful addition to the information bank that policymakers need in order to formulate consistent agricultural policies.

The Zairian Basin represents an important agroecological region in Africa, that, as is clear from the report, has immense problems that should be studied if the many people in the region are to participate actively in the development process. We particularly hope that this research, appropriately modified, will serve as a prototype for further analyses of the conditions for improvement.

This study, conducted in collaboration with the Institut Facultaire des Sciences Agronomiques (IFA), Yangambi, Zaire, was partially funded by the International Development Research Centre of Canada (IDRC). IFPRI and IFA are grateful to IDRC for its encouragement and consistent support of this and other research work on Sub-Saharan Africa.

John W. Mellor

Washington, D.C.
June 1989

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SUMMARY

Most agricultural projects initiated by the government of Zaire in the small-farm sector during the last two decades to improve a worsening food supply situation have failed mainly as a result of limited knowledge about constraints affecting the development of the sector. This study was undertaken to fill this gap. The study area is located in the Zairian Basin, which is part of a tropical rain forest zone. The zone includes large parts of Equateur, Haut-Zaire, Sud-Kivu, Maniema, Kasai Oriental, Kasai Occidental, and Bandundu regions, and a small part of the Bas-Zaire region. The Basin also extends beyond the Zairian boundaries to include a part of the Congo.

The Basin is ecologically more suited to perennial (tree) crops than to annual (food) crops. Most robusta coffee, cocoa, natural rubber, and palm oil trees are grown on plantations. The area is the major zone in the country for growing tree crops, as well as rice and plantain. Small-farm households primarily grow staple food crops, mainly rice, maize, cassava, and plantain.

Land is readily available in this sparsely populated zone. The mode of farming used by small farmers in the production of food crops is the slash-and-burn fallow system. Because of the fragility of the soils, a long fallow period is called for, preferably after every cropping season. Consequently, labor is required each crop year to open new plots of cropland by slashing, burning, and clearing. The poor state of roads and other infrastructure severely limits marketing possibilities for crops.

The study points up two basic facts: the amount of resources, particularly labor, allocated to farming in the Zairian Basin is small, even by African standards, and the productivity of these resources is also low. During the 1982/83 crop year, an average of 271 man-hours was devoted to agriculture per man-equivalent (which takes into account differences in age and sex) out of 776 man-hours devoted to economic activities. Farming's share of productive labor time was only about 34.9 percent. The remaining work time was allocated to hunting, fishing, gathering, handicrafts, and commerce. The study also reveals that only a small amount of capital was allocated to farming, and this was limited to a few hand tools and rice and maize seeds produced on-farm. On average, each household spent about 75.40 zaires (Z) on tools and Z25.34 on seeds during the 1982/83 crop year (Z5.75 equaled US\$1.00 in 1982/83). Because so little labor and capital (tools) were allocated to land preparation, the amount of area cultivated was also severely limited. A 1.00 percent increase in labor devoted to land preparation would increase cultivated area by 0.75 percent, and a 1.00 percent increase in tools would increase it by 0.25 percent. As it was, cultivated area per household was only 0.67 hectare, about 0.22 hectare per man-equivalent.

The analysis also indicates that, despite the small area cultivated, the amount of labor input per hectare was high compared with other parts of Sub-Saharan Africa and Asia—about 1,230 man-hours per hectare during the 1982/83 crop year. Overall, a 1.00 percent decline in cultivated area would increase labor use per hectare by 0.42 percent.

In the study area, labor was more productive on cassava and plantain than on rice and maize. The average product of labor was about 0.58 kilogram of cereal-equivalents per man-hour for rice and 1.22 kilograms for maize in 1982/83. For cassava, the productivity of labor was 6.62 kilograms and for plantain, it was 3.17 kilograms of

cereal-equivalents per man-hour. Overall, the productivity of labor input was estimated at about 3.08 kilograms in cereal-equivalents per man-hour, and labor input was the major contributor to overall food crop output in the Zairian Basin. Labor contributed 78 percent to food crop output and capital contributed 22 percent.

The study indicates that, given the current agricultural resource base, the productivity of labor input could be significantly increased if each household in the area were to allocate more labor to farming, especially to land preparation, because labor productivity increases with the size of cultivated area. Domestic terms of trade between crop and noncrop products and the availability of capital are the key variables affecting the amount of labor allocated to farming in the Zairian Basin. The elasticity of labor input devoted to farming per man-equivalent with respect to the domestic terms of trade of farm relative to nonfarm products was 0.38 and that with respect to capital input was 0.28.

Policies to improve domestic prices for farm products and the amount of capital input should include development of infrastructure such as roads; transportation, distribution, and marketing facilities; and rural capital markets. In addition, investments in new technology such as improved seeds and fertilizers offer some opportunity for improvement, particularly in the production of cereals in the area.

INTRODUCTION

Background and Objectives of the Study

Since the 1970s, per capita food and agricultural output in Sub-Saharan Africa have been declining as a result of the low land and labor productivities that characterize African smallholder agriculture. Economic studies have mostly approached the development problems of smallholder agriculture in terms of land-labor relationships, and in so doing, they have underestimated the role of capital in the development process (Cleaver 1974; de Wilde 1967). These studies have at least partly influenced agricultural policies and led many policymakers to believe that food and agricultural output can be increased mainly through land expansion. As a result, the introduction of capital inputs (such as fertilizer, high-yielding seeds, pesticides, irrigation, and equipment) and improved agricultural techniques in the small-farm sector, as well as the development of physical infrastructure and rural institutions, have received limited attention. This largely explains why the productivity of land and labor is currently so low.

In comparison, in Asia, where land expansion is no longer a feasible solution to growth in food and agricultural output as a result of high population pressure, researchers and policymakers reached a consensus that a fundamental structural change in the land-labor-capital relationship had to be initiated if a respectable growth in food and agricultural output was to be achieved. In the process, this consensus led to a policy framework that promotes extensive use by smallholders of capital inputs, which encompass both land-augmenting and labor-consuming technologies. This technological change has led to a substantial upward shift in the productivity of both land and labor in Asia (Hayami and Ruttan 1985; Mellor 1976).

Evidence pertaining to Sub-Saharan Africa suggests that the expansion of cultivated area in the region resulted in a modest increment in food output during the 1961-80 period, while the share of yield increase in the growth of food output was negligible (Paulino 1987). Consequently, the rate of growth of food output has not kept pace with population growth in the region. This situation has led to massive food imports, which have drained limited foreign exchange earnings and hence constrained the ability of the countries in the region to improve and expand the productive capacity of agriculture and of the rest of the economy.

Zaire is one of the countries in Sub-Saharan Africa where the food supply situation has been deteriorating at an alarming rate for at least two decades. The annual average growth rate of domestic staple food crop output, which was about 4.0 percent during 1966-70, declined to 1.6 percent during 1971-81. The annual average growth rate of cereal imports decreased from 11.2 percent during 1966-70 to 10.4 percent during 1971-81, due to restrictive trade and exchange rate policies. The annual average growth rate of the total staple food crop supply (including imports) declined from 4.1 percent during 1966-70 to about 1.8 percent during 1971-81, while the annual population growth rate was about 2.8 percent during the period (Tshibaka 1986).

The widening gap between food supply and population growth has created hardships for many of the people of Zaire. A 10-year field study on nutrition and health revealed that malnutrition has been spreading rapidly (World Bank 1980). Average calorie intake was only 80-90 percent of minimum requirements, indicating that food production

and imports fell short of meeting growing food needs. To reverse the trend, the Zairian government initiated a number of agricultural projects, including programs to expand production of rice, maize, cassava, and pulses, and introduction of grain marketing boards and farmer cooperatives. Most of these projects failed to meet expectations (Kapambwe 1974; Lititiyo 1977). Limited empirical evidence indicates that they were formulated and implemented with little knowledge about key constraints affecting the development of the small-farm sector. For example, in the rain forest zone known as the Zairian Basin, it was found that the pattern of labor allocation among different household activities constitutes one of the major constraints to increased farm output. A survey conducted in 1974/75 on a small sample of 17 households in the Zairian Basin, specifically in Yalibwa, Turumbu Community, indicated that farming claimed only 11 percent of adult male labor time and 27 percent of adult female time (Tshibaka 1975).

A detailed study of the farming system was needed to reveal not only the key determinants of labor allocation, but also other major constraints to increased food output. To this end, this study examines the following basic questions. First, what is the household resource base for small farmers? Second, how are these resources allocated between farming and nonfarming? Third, what are the key determinants of this resource allocation, and what are the implications for the farm sector? And fourth, what is the level of resource productivity, and what actions need to be initiated to improve it?

Data Source and Limitations

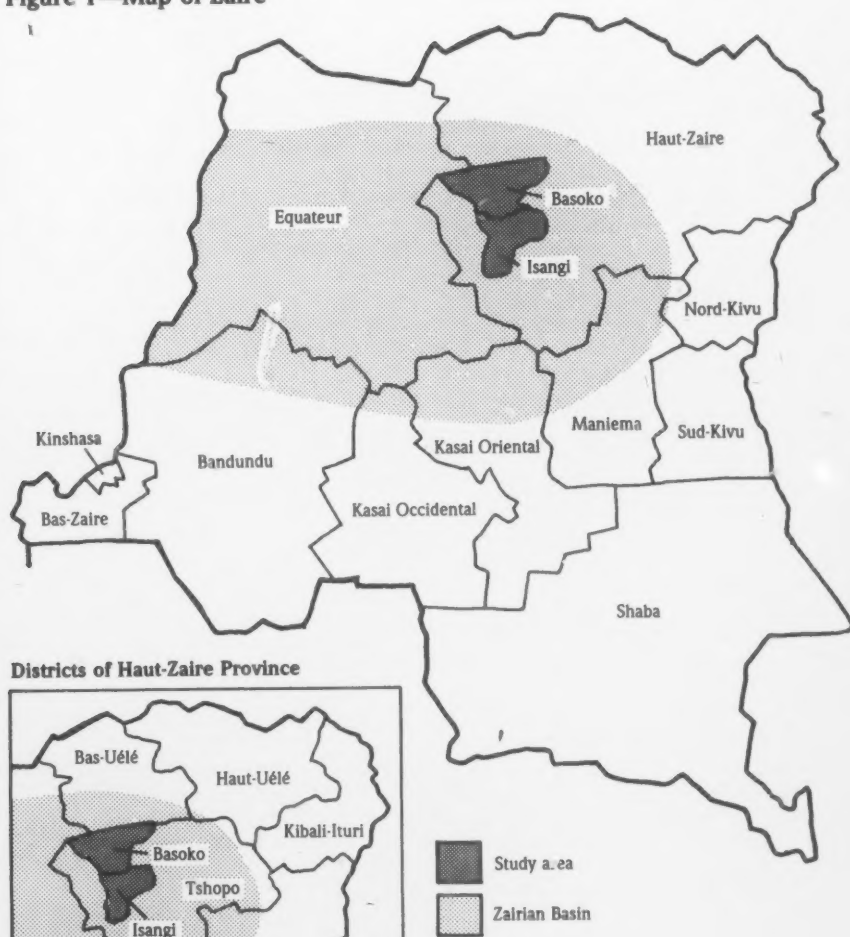
A joint study by the Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and the International Food Policy Research Institute, Washington, D.C., was undertaken with the support of the International Development Research Centre of Canada to provide basic data that could help the government of Zaire formulate consistent agricultural policy to enhance the production of rice and other food crops in the Zairian Basin in particular and in the country as a whole.

The Zairian Basin is part of a tropical rain forest that covers almost 40 percent of the Zairian land area. Tree crops—robusta coffee, palm oil, rubber, and cocoa—are mainly grown in this forest zone. The zone is also the major growing area for rice, cassava, and plantain in the country. Zaire is currently divided into 11 regions (provinces): Kinshasa, Equateur, Haut-Zaire, Maniema, Nord-Kivu, Sud-Kivu, Shaba, Kasai Oriental, Kasai Occidental, Bas-Zaire, and Bandundu. The rain forest includes a part of each of these provinces, except Kinshasa and Shaba. Each province (region) is, in turn, divided into districts (subregions) and each district into zones (counties).

The data used in this research report were derived from a cost route survey conducted from September 1982 to August 1983 by the author in Turumbu, Mongandjo, and Bomaneh rural communities located in Isangi and Basoko zones, Tshopo District. This subregion is located in the rain-forest part of Haut-Zaire Province (see Figure 1).¹ The study area covered in the survey was divided into six subareas on the basis of available infrastructure (the road network system), and a sample of 180 households, 30 from each subarea, was drawn. To increase the sample efficiency (to lower the sampling variance), the 30 households were chosen following a proportionate, stratified

¹ This type of survey has been widely used in Africa. For detailed information, see: Purdue University (1980), Zuckerman (1979), Matlon et al. (1979), Shapiro (1973), Norman (1973a), Elliott et al. (1970), and Winch (1976).

Figure 1—Map of Zaire



Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

sampling procedure (Rossi et al. 1983; Upton 1973). First, a number of villages were randomly drawn in each subarea. Second, taking account of the population of selected individual villages, a given number of households were randomly drawn in each village.

One enumerator and an aide were posted in each subarea for one crop year. Two research assistants were allocated to the project to help supervise the survey. Selected households were visited by enumerators four times a week for one crop year and two techniques of data collection were used: interview and direct measurement. For various reasons, 48 households did not provide all the required data, and were eliminated. Hence, at the end of the survey, data from only 132 households were retained. Data were collected on population, infrastructure, input, output, and prices. Enumerators measured perimeters and triangles of land under crops using tape measures, compasses, and pickets, and cultivated area was estimated by the triangulation method.

The most serious limitation of this type of survey has always been the assessment of time spent on different activities, which is affected by farmers' own judgment and that of the enumerators. With regard to capital, farmers do not easily recall the monetary value of their tools and the date of acquisition. These limitations are hard to avoid in a situation where most farmers are illiterate or do not keep records.

In a system where mixed cropping is the most prevalent mode of production, the estimation of cultivated area, labor, and capital allocated to individual crops presents a number of unresolved practical and methodological problems. To circumvent these difficulties, the researcher is tempted to convert all food crop outputs into cereal equivalents and to proceed with the computation of input/output relationships without having an idea of how much area is allocated to individual crops. This approach is inappropriate for a number of reasons. First, there is a hierarchy of crops in mixed cropping. There are major and minor crops in the same field. For example, other things remaining the same, a field sown mainly with rice is different from a field mostly planted with cassava, both in resource requirements and yields expressed in cereal equivalents. Hence, an estimate of the share of area allocated to each crop is indispensable for reflecting the effects of various crop mixes. Second, it would be difficult to answer a number of crop-specific questions that are of policy interest if crops were lumped together, such as the productivity of resources used in the production of individual crops.

A statistical method proposed by the Institut National des Statistiques et d'Etudes Economiques de France was adopted to estimate the cultivated area allocated to individual crops. For a description of this method, see Appendix 1. The proposed method, notwithstanding its limitations, provides estimates that are useful when studying a mixed-crop farming system (Norman 1972).

The allocation of time spent on nonspecific farm operations such as land preparation and weeding among individual crops was performed on the basis of area shares of individual crops. For capital tools—mainly hoes, cutlasses, and hatchets—the labor time allocated to each of the four crops expressed as a fraction of total labor time devoted to farming was used as a weight to calculate the depreciation of capital tools (in zaires) used in the production of each of the crops. This approach is supported by the fact that most of the tools used in the area are hand-held; therefore, their use is highly correlated with labor input per crop. For example, tools must be used much more extensively on 1 hectare of rice than on 1 hectare of plantain. To estimate crop densities and yields, a yield plot method was used (see Appendix 1).

3

THE STUDY AREA

Ecology of the Study Area

The study area is part of the Zairian Basin, a forest zone in the humid tropics of Africa. Rainfall averages about 1,800 millimeters a year with bimodal precipitations. There are two rainy seasons—one between March and May and the other between August and November—and two dry seasons—one between January and February and the other between June and July.

The area receives an average of 1,972 hours of sunshine per year, representing 45 percent of the days of possible sunshine, most of it concentrated during the drier periods of the year. The limited sunshine constitutes an important ecological constraint to crop production. Temperatures in the area average 25.5° C (Crabbe 1970; Bernard 1945).

Soils are leached. High surface heat and hard, frequent rains lead to rapid breakdown of organic soil materials (Sanchez 1976). As a result, fertility is low. Once land is cleared and put under cultivation with annual crops, soils are rapidly depleted. The forest that covers the Zairian Basin is rich in flora and fauna. Birds, pests, and diseases constitute a major environmental threat to food crop production in this area.

Small-Farm Agriculture in the Zairian Basin

The small-farm sector, the core of this study, includes subsistence-oriented farmers who cultivate less than 5 hectares of land each crop season. Inputs are limited to simple hand tools such as cutlasses, hoes, and hatchets, on-farm crop seeds, and household labor. Use of hired labor is uncommon in the area. Land is abundantly available to every household. All the staple food crops—cassava, plantain, maize, and rice—are produced under a mixed cropping system.

Small-farm production of robusta coffee is negligible and production of cocoa and natural rubber by small farmers is almost unknown. None of the households selected in the sampling process produces coffee. A substantial share of households, however, exploit wild palm oil trees. Since the palm oil tree is a native of tropical Africa's rain forest, which includes the Zairian Basin, the small farmer's production of palm oil is considered to be a gathering rather than a farming activity. As for livestock, the rain forest zone of Sub-Saharan Africa is not suitable, especially for cattle raising, because of the tsetse. Although a few households keep a small number of goats, pigs, or chickens, livestock raising as an economic activity is negligible. The study area derives most of its animal protein requirements from hunting and fishing.

The forest area of the humid tropics of Africa is ecologically more suitable to perennial (tree) crops than to annual (food) crops (Jurion and Henry 1967). Since the colonial era, the Zairian Basin has been the major tree-growing area in the country. The main tree crops produced are robusta coffee, cocoa, natural rubber, and palm oil for export. These crops are mainly produced on privately owned, large-scale plantations, using modern equipment and machinery, hired labor (who live on the plantations), and modern agricultural and managerial techniques. Because roads in the study area have deteriorated drastically, few plantations are now operating there.

Tree crop agriculture uses the land—the most abundant resource in the country—most intensively, and it approximately recreates the natural environment by replacing the natural forest with an artificial one made up of tree crops. As such, its negative effect on the environment, particularly on soil and forest conservation, is small. In contrast, small-farm agriculture uses the land extensively under a shifting mode of cultivation. That is, the same farm fields are planted with a mix of rice, maize, cassava, and plantain. Maize is harvested three months after sowing, and rice in four, whereas cassava and plantain occupy the land for a period that extends into the new cropping season, hence compelling farmers to open new plots of forest or fallow at the beginning of each cropping season. When cassava and plantain crops are harvested, the fields are then left fallow. Under this cassava-based system, farm fields are generally cropped for one season and then left fallow for a number of seasons.

It follows then that, from a long-run ecological standpoint, in the Zairian Basin, the appropriate small-farm agriculture to promote is a tree crop production system. Once food markets begin to operate adequately, small farmers could purchase food, but in the short run food can be produced for home use at much lower factor returns than in tree crop production. The logical tree crops to promote among small farmers are palm oil, coffee, and cocoa.

The first step in an effort to enhance regional crop specialization in the country is to initiate a well-planned, long-term investment program to develop infrastructure such as roads, river transport, and distribution and marketing channels.

Study Population

The study area, located in Haut-Zaire Province, Tshopo District, includes three communities: Turumbu people in the administrative zone of Isangi; Basoo people in Bomaneh, Bomenge Rural Community; and Bangelima people in Mongandjo Community in the administrative zone of Basoko.

These ethnic groups mainly depend on farming, hunting, gathering, and fishing for their living. The total population of the area was estimated at 49,103 people in 1981. Its annual population growth rate was estimated at about 1.2 percent, which was substantially lower than the national average growth rate of 2.8 percent per year (Zaire 1983).

Data are drawn from 53 households in Turumbu Community, 53 households in Mongandjo, and 26 households in Bomaneh, Bomenge Community (see Table 1). The sample population of 885 people is 48.1 percent male and 51.9 percent female.

The most productive age group, the 20-55 age bracket, accounts for 16.5 percent of males and 22.7 percent of females. The 15-19-year-olds, the group that will be most productive in the near future, includes 4.1 percent of the males and 3.4 percent of the females. The age groups under 15 and above 55 account for 27.6 percent of the males and 25.8 percent of the females.² The sample population of 885 people represents a total labor force of 400.8 man-equivalents of which 217.6 are males and 183.2 are females. The factors used to convert people of different ages and sexes to man-equivalents are given in Appendix 1.³ This gives an average of 3.9 man-equivalents per household in Turumbu, 2.5 in Mongandjo, 2.4 in Bomaneh (Bomenge), and 3.0 in the study area

² In Zaire, farmers more than 55 years old are regarded as retired.

³ For more details see Collinson (1972). The total number of man-equivalents per household are given in Appendix 1, Table 28.

Table 1—Structure of the sample population in the study area

Sex/ Age Group	Turumbu Villages			Mongandjo			Bomenge	
	Yangambi-Kisangani Road ^a	Weko and Yambaw	Yangambi-Isangi Road ^b	Total Turumbu Community	Bolikongo	Babendja	Total Mongandjo Community	Bomanah
	(number of people)							
Males								
Less than 1 year old	2	3	0	5	1	0	1	6
1-4 years	12	15	9	36	12	6	18	8
5-9 years	9	9	12	30	13	12	25	14
10-14 years	13	8	6	27	3	9	12	9
15-19 years	14	5	6	25	6	1	7	4
20-55 years	26	24	27	77	21	21	42	27
More than 55 years old	5	10	8	23	12	16	28	2
Total males	81	74	68	223	68	65	133	70
Females								
Less than 1 year old	2	6	4	12	3	3	6	7
1-4 years	9	5	9	23	6	7	13	14
5-9 years	12	12	13	37	9	11	20	9
10-14 years	7	8	5	20	3	8	11	9
15-19 years	5	9	9	23	4	0	4	3
20-55 years	34	31	30	95	35	34	69	37
More than 55 years old	6	9	4	19	14	14	28	0
Total females	75	80	74	229	74	77	151	79
Total number of people	156	154	142	452	142	142	284	149
Number of households	17	17	19	53	25	28	53	26

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

^a Households in this group are located along the Yangambi-Kisangani Road up to 22 kilometers from Yangambi.

^b Households in this group are located along the Yangambi-Isangi Road up to 20 kilometers from Yangambi.

as a whole. The 20-55 year age group, relatively more involved in farming, accounts for 70.0 percent of the overall sample of which 36.4 percent are males and 33.6 percent females.

Basic Infrastructure in the Study Area

The Zairian Basin is the least developed region in the country, which is reflected in the poor state of the road network and consequently the transportation system.

Most villages in the region are isolated or poorly connected to major markets and urban centers. There are differences from one group of villages to another in physical condition of the roads and distances to rural markets or urban centers, making some villages more accessible than others. Most Turumbu villages are served by the Zaire River and the Isangi-Yangambi-Kisangani road. Local traders provide the sole means of transportation on the river, the traditional canoe. The traders are Lokele people, who play an important role in the distribution and marketing of farm and nonfarm commodities produced by Turumbu farmers. Although canoes are used all year round, the volume of goods transported remains small, and the risk of shipwreck high.

The Isangi-Yangambi-Kisangani road, considered to be a major national road, is unpaved. Even during relatively dry periods of the year, the use of this road by vehicles is limited. The 97 kilometers that separate Yangambi and Kisangani may be covered in three hours in the best of weather conditions. During wet periods, the road is seldom used by vehicles. The high level of precipitation in the Zairian Basin makes the use of unpaved roads by vehicles difficult during most of the year. As a result, Turumbu villages along this axis are poorly connected to Yangambi and Lotokila—the major local markets in the community—as well as to Kisangani, the major urban center. Farmers living along this road usually walk 4-23 kilometers, depending on the location of their villages, to reach a rural marketplace.

A second group of Turumbu villages, even more isolated, includes Weko and Yambaw in the remote forest. The road connecting these villages to Yangambi has deteriorated to such an extent that it is no longer used by vehicles at all. Farmers bring their produce twice a week to a local marketplace (which is 1 kilometer from Weko and 12 kilometers from Yambaw) for sale to traders, most of whom come from Yangambi by foot or bicycle. The distance from this local market to Yangambi is about 42 kilometers.

In Mongandjo Community, farm households are served by the Aruwimi River and two feeder roads. The 42-kilometer road connecting Bolikango to Basoko is the best maintained in the entire study area. It was in fair condition for seven months of the survey year, in poor condition for three months, and in very poor condition for two months. Farmers walk on foot 5-23 kilometers to reach three rural markets: Longote, Bokote, and Baonde. The first two rural marketplaces are along the Aruwimi River, while the third one is at the point where the Basoko-Baonde route crosses the Aruwimi River. Farm and nonfarm products sold there are transported by traditional canoes or vehicles to Basoko, an important river port and marketplace.

The 190-kilometer road connecting Babendja in Mongandjo Community to Basoko is the second best road in the area. This road was in fair condition for five months, and in poor or very poor condition for the rest of the 1982/83 crop year. Babendja farmers walk 4-13 kilometers to reach a local market, where farm and nonfarm products are sold and transported to Basoko either by road or by the Aruwimi River. The Aruwimi River is used all year round by small boats and canoes. The distance by water from Babendja to Basoko is about 105 kilometers.

The 21-kilometer road connecting Bomaneh to Basoko in Bomenge Community is no longer practicable for vehicles, and it is now left entirely to those on foot. Only the Aruwimi River connects Bomaneh farmers to the two marketplaces, Baonde, 23 kilometers away, and Basoko, 24 kilometers. Canoes and small boats are the means of transportation used by farmers to reach these rural marketplaces.

Table 2 summarizes data on the conditions of the roads and the navigability of rivers in the area. It shows that Mongandjo and Bomaneh (Bomenge) farmers are in a somewhat better position than Turumbu farmers. The negative impact of this poor road network on the development of local marketing channels cannot be overemphasized. In all, the transportation system in the study area is grossly inadequate. For this and other reasons, few plantations are now operating in the study area, and none of the surveyed households were employed by plantations. This low level of infrastructural development constitutes one of the most important constraints to increased food and agricultural output in the area.

Distribution, Marketing, and Pricing of Farm Products

The distribution, marketing, and pricing of farm and nonfarm products were regulated under different policy regimes until September 1983, when prices of all farm and most nonfarm products were liberalized, and restrictions imposed on domestic trade were lifted (Tshibaka 1986).

The distribution of cassava, plantain, other root and tuber crops, game meat, fish, handicrafts, and products from gathering have never been controlled by the Zairian government. The demand and the supply of these products were and continue to be

Table 2—Practicability of roads and navigability of rivers in the study area, 1982/83 survey

Transport Route Destinations	Condition of Road/River			Distance from Primary (Local) to Secondary Markets	Community Served	Villages Served
	Fair	Poor	Very Poor			
	(number of months)			(kilometers)		
Yangambi-Kisangani road	0	5	7	97	Turumbu	Villages along the Yangambi-Kisangani road
Yangambi-Weko	0	0	12	42	Turumbu	Villages in remote forest (Weko and Yambaw)
Yangambi-Isangi road	0	5	7	97	Turumbu	Villages along the Yangambi-Isangi road
Basako-Baonde road	7	3	2	47	Mongandjo	Bolikango
Basoko-Mongandjo (Aruwimi River)	8	4	0	105	Mongandjo	Babendja
Basoko-Bomaneh (Aruwimi River)	8	4	0	24	Bomenge	Bomaneh

Source: Based on data from Tshibaka B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Economiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: For rivers, "fair" indicates navigable and "very poor," not navigable.

regulated by domestic market forces. But crops such as rice, maize, groundnuts, cotton, coffee, tea, palm oil, cocoa, and rubber were subject to government control until September 1983.

Due to the poor state of the road network in the study area, the distribution, marketing, and pricing of rice and maize were not totally enforced. But rice millers who were able to reach the villages applied some political pressures to persuade farmers to accept the official price for their paddy rice. A substantial portion of paddy, however, was and still is converted into rice at the household level, using mortar and pestle. This is the traditional method used in every part of the country where rice is grown. Although the method produces a low-quality product from a commercial standpoint with a significant amount of broken rice, the nutritional value of the rice is preserved, as most vitamins and minerals are retained. This rice product is sold by female farmers in the local market to any potential trader or consumer at the market price. Regarding maize, most of it is converted into an alcoholic drink favored in the study area. The price of this drink is determined by local market conditions. Rice and maize are the major source of cash income from farming in the study area.

At the local level, three groups of participants carry out most of the distribution and marketing of farm products. These include farmers, small transporters, and petty traders, most of whom are women. Cassava products offered for sale by farmers are fresh roots, dry roots, *chickwangu* (cassava bread), and leaves (Tshibaka and Lumpungu 1989). Fresh plantain, paddy rice, milled rice, and maize grains are the most common forms in which plantain, rice, and maize are offered for sale by small farmers. Because the infrastructure—roads and other transportation facilities—is inadequate in the study area, leaves, fresh cassava roots, *chickwangu*, and plantain have a limited marketing area. Being the most perishable, they are generally sold in the local markets. From this description, the critical role of infrastructure in distribution and marketing is apparent, as well as the need to promote the processing of farm produce into products that can be stored and marketed over long periods of time.

LAND AND CAPITAL INPUTS

At the outset, it should be noted that this study is based on an implicit assumption that all the resources allocated to the small-farm sector are used up in the production of the four major crops, namely rice, maize, cassava, and plantain. Although minor crops such as vegetables and fruits are also produced, they are not considered here.

Land and Related Aspects

Land Tenure System

Although the constitution of Zaire stipulates that land and all natural resources belong to the state, Zairian ethnic groups still consider certain lands their property. In the study area, all of the household heads interviewed affirmed that all members of the clan, regardless of sex, religion, or political affiliation, have free access to land and other natural resources (forests, streams, and rivers) belonging to the clan. These resources are common property and cannot be alienated.

The traditional land tenure system in the area, however, seems to be tacitly moving toward private ownership of land. Sixty-four percent of the surveyed household heads interviewed affirmed that every household retains the right to use their fallow land. This right is extended to household male descendants. In practice, this amounts to private ownership of land. One should note that this practice does not imply that land is scarce in the area. Indeed, the population density does not exceed five persons per square kilometer.

Furthermore, the survey shows that in Turumbu Community payment in cash or kind by nonmembers of the clan is accepted where the right to fallow land is recognized.⁴ Among Bangelima and Basoo in Mongandjo and Bomenge, there is no correlation between payment and the right to use fallow land. Table 3 presents this data. It should be stressed that payments are in no circumstances regarded as a sale price of land or as rent.⁵ From the traditional point of view, land cannot be bought or sold. It remains a common property of the clan, and the nonmember is allowed to use it as long as he lives with the clan or has not fallen under disgrace.

These are only a few aspects of the complex traditional land tenure system related to farming, which varies from one clan to another within the same ethnic group. A common feature of all these traditional land tenure systems is that land and other natural resources are common property.

Regarding the government's role in land use and management, 69.6 percent of farmers interviewed believed that the government should play a monitoring role. The rest of the farmers considered government intervention likely to create additional problems.

⁴ The first household to open a piece of land keeps the right to use that land as long as household members continue to live in the village, unless they state explicitly that they are no longer interested in it. At that time, the land returns to the common pool.

⁵ The payment is made only once, which differs from rent that has to be paid continuously as long as the land is being used. It is given by the nonmember of the clan in appreciation for the right to use the land, which the clan has extended.

Table 3—Community recognition of practices of right of fallow and lease of land to nonmembers in study area

Rural Community	Number of Household Heads Interviewed	Community Accepts Payment for Land	Community Recognizes Right of Fallow
		(percent)	
Turumbu			
Yangambi-Kisangani road ^a	17	65.4	100.0
Weko and Yambaw	17	4.8	9.0
Yangambi-Isangi road ^b	19	23.8	60.0
Mongandjo			
Bolikango	25	0.0	8.0
Babendja	28	7.1	25.0
Bomenge			
Bomaneh	26	0.0	80.8

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

^a The households in this group are located up to 22 kilometers from Yangambi.

^b The households in this group are located up to 20 kilometers from Yangambi.

Land Quality

Many of the farmers interviewed claimed that the presence of certain tree species provides a good indication of soil fertility. This technique, although crude, has some scientific backing. About 79.7 percent of the household heads attested that forest area to be cleared for farming was selected based on this method.

Once the selection of forest area is made, the traditional head of the clan, in collaboration with an agricultural agent, delimits and divides the area among various farm households within the limits of each household's resources. This practice, instituted by the Colonial Administration to ensure an orderly use of the forest for agricultural purposes, is still observed today. About 81 percent of the households surveyed had their farm fields in the portion of forest preselected for farming in 1982/83. The rest of the households had their farm fields scattered in the forest.

Land Availability and Use

Exact data on land area held by individual clans are not available. All household heads interviewed agreed that land is not a constraint to production. It is abundant and available to any member of the clan. For instance, the Turumbu Rural Community, with a population of 29,532 in 1981, had an area of 4,000 square kilometers. This represents a density of about seven persons per square kilometer. It should be stressed, however, that the area of land that can be cropped is limited by the fact that hand tools have to be coupled with human force to clear the land, an especially energy-consuming activity in the forest zone. The Zairian Basin is clearly a land-surplus, labor-scarce area.

About 80.5 percent of the households exploit the land for two cropping seasons before putting it to fallow. Table 4 shows that 41.9 percent of the households leave their fields to fallow for a period of time ranging from three to six years, while the remaining 58.1 percent of the households put their fields to fallow for at least seven years.

Several measurable changes in tropical soil characteristics occur during the cultivation period, including increased acidity, decreased levels of available plant nutrients,

Table 4—Length of fallow period, by households surveyed, 1982/83

Fallow Period (years)	Percent of Surveyed Households
Less than 4	4.0
4	5.3
5	17.3
6	15.3
7	14.7
8	11.3
9	6.7
10	10.7
More than 10	12.7
Forest*	2.0
Total	100.0

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

* Two percent of the households surveyed had plots in the primary forest.

loss of organic matter, greater compaction, decreased storage of available water, and decreased infiltration capacity. Marked changes in the faunal population and microbiological activity also occur. These detrimental changes undoubtedly influence crop yields increasingly as cultivation is extended beyond one or two cropping cycles or the length of the fallow period is reduced. A minimum fallow period of seven years is necessary to maintain soil fertility in the tropics under a traditional farming system (Greenland and Okigbo 1983).

A minimum fallow period of 10 years was instituted during the Colonial Administration. Most measures initiated during this period were enforced through coercion rather than persuasion (Jurion and Henry 1967). This allegation does not imply, however, that all the measures taken during the period before independence were wrong or unnecessary.

A positive question one should ask is why did a substantial share of farmers shorten the fallow period to less than seven years despite the low population density? One possible explanation may be that reducing the labor input required for clearing by shortening the fallow period could well be an attempt to increase labor productivity where opportunity costs for labor are rising, at least outside the farm sector.

The effects of shortening the fallow period on the intensities of labor and capital use, as well as on the productivities of land, labor, and capital, will be examined subsequently in order to make an economic judgment on farmers' behavior.

Allocation of Cultivated Area among Crops

The cultivated area per household (0.67 hectare) and the cultivated land per man-equivalent in the study area (0.22 hectare) are small by any standards (Table 5). Perreault (1978) found that the cultivated area per household was 0.88 hectare for Yalenge village, 0.94 hectare for Banakanole, and 0.82 hectare for Yambela in the Zairian Basin. All these estimates are smaller than those reported in other regions of the country. Durocher (1983) estimated an average cultivated area of 1.02 hectares per household in Nande Rural Community, Nord-Kivu, and Ntamulyango (1975) re-

Table 5—Cultivated land/man ratio and allocation of cultivated area among crops

Rural Community	Number of Households	Man-Equivalents/ Household	Cultivated Area/ Household	Cultivated Area/Man-Equivalent	Allocation of Area			
					Rice	Maize	Cassava	Plantain
			(hectare)		(percent)			
Turumbu	53	3.88	0.66 (0.51)	0.17	27.61	26.92	33.14	12.32
Yangambi-Kisangani ^a	17	4.24	0.85 (0.77)	0.20	9.13	37.65	32.73	20.49
Weko and Yambaw	17	3.99	0.50 (0.25)	0.13	52.15	21.57	23.29	2.99
Yangambi-Isangi ^b	19	3.46	0.63 (0.35)	0.18	22.19	22.11	42.33	13.37
Mongandjo	53	2.52	0.75 (0.33)	0.30	39.19	9.33	51.48	0.00
Bolikango	25	2.68	0.73 (0.32)	0.27	32.13	11.97	55.90	0.00
Babendja	28	2.37	0.77 (0.34)	0.32	45.50	6.97	47.54	0.00
Bomenge Bomaneh	26	2.38	0.53 (0.33)	0.22	8.75	34.99	54.58	1.68
Study area	132	3.04	0.67 (0.42)	0.22	28.55	21.45	44.73	5.28

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The numbers in parentheses are standard deviations.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

ported an area of 1.48 hectares per household in Bushumba, Sud-Kivu. These figures are not given for comparative purposes. The areas mentioned in these two Kivu regions are in savannah zones. Land preparation requires more energy in the forest zone than in the savannah. In all, the cultivated area per household and cultivated land-man ratio remain small despite the availability of land, both in the Kivu regions and in the Zairian Basin. The key factors affecting the size of cultivated land area and the implications for farm output and labor productivity will be considered later.

Crop area estimates reported in Table 5 show wide intercommunity variability. In Turumbu, cassava claims the largest share of the cultivated area. Rice, maize, and plantain are second, third, and fourth. In Mongandjo, cassava has the largest share of area followed by rice and maize. In Bomaneh, Bomenge Rural Community, cassava occupies the first position; maize, the second; rice, the third; and plantain, the fourth. Overall, cassava covers the most area, followed in decreasing order by rice, maize, and plantain.

Variability in the shares of area devoted to individual crops among villages within the communities reflects both local market conditions and the degree of access to markets in the major centers. The communities with relatively large local markets tend

to allocate more of their cultivated area to cassava, maize, and plantain. The Turumbu villages located along the Yangambi-Kisangani road allocated 90.8 percent of cultivated area to cassava, maize, and plantain, and those along the Yangambi-Isangi road 77.8 percent, with rice claiming the rest. These villages have relatively large local markets (at Yangambi, Lotokila, and Isangi), compared with Weko and Yambaw, which are located in remote forest areas without substantial local markets. They are connected to Yangambi by a very poor road of about 42 kilometers. In Weko and Yambaw, households allocated 52.2 percent of cultivated area to rice alone. Because of its biological nature, rice can be stored and sold over a relatively longer period of time than maize, cassava, and plantain. Therefore, in a remote area without a large local market and poorly connected to major centers, farmers tend to allocate more of their cultivated area to crops that can be stored under farm conditions with limited loss. For this reason, rice has become the major cash crop in poorly connected, remote areas of the Zairian Basin.

This same pattern of land allocation between rice, cassava, and maize also holds for Mongandjo Community. (Production of plantain in Mongandjo is severely constrained by monkeys.) In Bolikango, which is much closer to the major market of Basoko than Babendja, farm households allocated 67.9 percent of the cultivated area to cassava and maize as opposed to 54.5 percent in Babendja. Farmers in Bolikango devoted about 32.1 percent of the cultivated area to rice as opposed to 45.5 percent in Babendja. In Bomaneh, rice is a new crop that was introduced into the farming system in 1981/82. A comparison of rice and other crops does not hold for this community.

Capital Input

As stated earlier, capital inputs available to the peasant farmer include a few hand-held tools and rice and maize seeds produced on-farm.

Quantity of Rice and Maize Seeds Used

The quality of seeds being used in the Zairian Basin has severely degenerated since independence in 1960, because until recently, no seed service existed in the country.⁶

Although data on technically optimal quantities of seeds to be used in a mixed-cropping system are not available, Table 6 indicates that, for the area as a whole, farmers used 59.6 percent for rice and 79.3 percent for maize of the quantity recommended for use in pure cropping by the Institut National d'Etude et de la Recherche Agronomique du Zaïre (INERA 1971).

There is a great deal of divergence among communities and also among villages. For Turumbu Community, the amount of rice and maize seeds used per hectare represents 50.5 percent and 67.0 percent respectively of the amount recommended for pure cropping. In Mongandjo Community, 63.0 percent of rice seeds and more than 100.0 percent of maize seeds were sown. In Bomaneh, rice seeds amounted to 67.3 percent of the quantity recommended for pure stands, and maize seeds, 62.0 percent. On the basis of these data, it seems likely that farmers who planted maize in Mongandjo in 1982/83 used too much maize seed per hectare for mixed stands, rather than too little. For the sample as a whole, 60.6 percent of surveyed households produced rice and 62.1 percent produced maize in 1982/83.

⁶ A new seed project sponsored by the World Bank was established in 1985 and is now operational. It has to be given some time, however, before its impact on the small-farm sector can be assessed.

Table 6—Quantity of seeds used per hectare by households that produce rice and maize, 1982/83

Rural Community	Number of Households Producing		Amount of Seeds Used in Mixed Cropping		Amount of Seeds Used in Mixed Cropping as a Percent of Amount Recommended in Pure Cropping	
	Rice	Maize	Rice	Maize	Rice	Maize
			(kilograms/hectare)		(percent)	
Turumbu	23	38	25.26 (5.26)	20.09 (6.66)	50.52	66.97
Yangambi-Kisangani road ^a	4	14	29.93 (2.22)	22.11 (5.99)	59.86	73.70
Weko and Yambaw	12	16	25.47 (5.27)	21.64 (6.68)	50.94	72.13
Yangambi-Isangi road ^b	7	8	22.23 (4.76)	13.45 (2.88)	44.46	44.83
Mongandjo	53	31	31.50 (7.23)	30.48 (7.26)	63.00	100.16
Bolikango	25	20	32.71 (8.04)	30.44 (7.99)	65.42	101.47
Babendja	28	11	30.41 (6.37)	30.57 (6.07)	60.82	101.90
Bomenge						
Bomaneh	4	13	33.66 (19.99)	18.60 (4.12)	67.32	62.00
Study area	80	82	29.81 (8.12)	23.78 (8.38)	59.62	79.27

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Standard deviations are in parentheses.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

Tools

Because most of the tools used were hand-held, their use was highly correlated with labor time allocated to each crop. Thus, labor shares of individual crops were used as weights to estimate the depreciation of tools allocated to these crops during the 1982/83 crop year. The estimated average depreciation of tools (material capital) per household in the study area as a whole was about Z75.40 for the year (Table 7).⁷

A crop-based comparison shows that 42.5 percent of the tools in the study area were used on rice, followed by 40.4 percent on cassava, 15.1 percent on maize, and 2.0 percent on plantain. Table 7 also indicates much variability between and within communities in the amount spent on capital input (tools) and in allocation among

⁷ The same tools are used in the production of rice, maize, cassava, and plantain. In dollar terms, the cost of tools used per household was about US\$13.11, using the official 1982/83 exchange rate of Z5.75/US\$1.00.

Table 7—Allocation of capital tools among crops, 1982/83

Rural Community	Number of Households	Cost of Capital Tools (Z)	Share of Tools Allocated (percent)			
			Rice	Maize	Cassava	Plantain
Turumbu	53	49.52 (58.80)	41.52	21.98	31.61	4.88
Yangambi-Kisangani road ^a	17	43.33 (57.93)	27.29	29.60	35.06	8.05
Weko and Yambaw	17	47.64 (60.21)	57.47	13.55	26.73	2.25
Yangambi-Isangi road ^b	19	56.74 (60.73)	38.25	23.50	33.43	4.82
Mongandjo	53	98.51 (45.93)	49.30	7.36	43.14	0.20
Bolikango	25	84.12 (51.59)	45.84	7.69	46.29	0.18
Babendja	28	111.36 (36.53)	53.14	7.06	39.58	0.24
Bomenge Bomaneh	26	81.06 (44.36)	18.36	25.62	54.87	1.15
Study area	132	75.40 (55.49)	42.52	15.09	40.40	1.99

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Standard deviations are in parentheses.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

crops. These inter- and intracommunity differences in capital input are also a function of cultivated land area.

Allocation of Seeds and Tools among Crops

Table 8 summarizes the data on capital input (seeds and tools) used per household, by crop. Rice received 48.7 percent of total capital input; cassava, 32.8 percent; maize, 17.2 percent; and plantain, 1.3 percent. Hand tools contributed a much larger share to capital input costs than seeds.

A community comparison indicates that Mongandjo allocated more capital input to farming than Bomaneh and Turumbu. An average household in Mongandjo spent 1.4 times more on capital than an average household in Bomaneh and 1.8 times more than in Turumbu.

In sum, this survey shows that capital input is in short supply in the small-farm sector of Zaire. All farmers interviewed suggested that the lack of an input delivery system, credit facilities, and adequate roads constitute the main constraints to increases in food output and income.

Table 8—Allocation of capital input (seeds and tools) among crops, 1982/83

Rural Community	Number of Households	Total Cost of Capital Input	Share of Total Capital Input Allocated			
			Rice	Maize	Cassava	Plantain
		(Z)				(percent)
Turumbu	53	72.39 — (76.06)	47.25	25.10	23.97	3.68
Yangambi-Kisangani road ^a	17	72.39 (91.00)	39.92	29.45	25.65	4.98
Weko and Yambaw	17	66.45 (76.30)	64.20	12.73	20.48	2.59
Yangambi-Isangi road ^b	19	71.69 (64.11)	40.38	30.94	25.24	3.44
Mongandjo	53	130.90 (55.94)	59.70	7.73	32.46	0.12
Bolikango	25	117.44 (63.19)	57.55	8.85	33.50	0.09
Babendja	28	142.92 (46.47)	61.27	6.90	31.69	0.14
Bomenge						
Bomaneh	26	97.09 (51.15)	20.85	31.32	46.96	0.87
Study area	132	100.74 (68.80)	48.73	17.22	32.76	1.29

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Cassava cuttings and plantain shoots to be planted are collected from previous farm fields by farmers themselves. The time spent on this activity is included in the labor input. Cassava cuttings and plantain shoots are neither bought nor sold in the study area. Tools constitute the only items of capital input used in the production of these two crops in the area. The prices of rice and maize seeds used to compute the value of seeds are reported in Appendix 2. The numbers in parentheses are standard deviations.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

LABOR USE AND ALLOCATION

This chapter presents the calendar of farm operations, the monthly intensity of labor use during the 1982/83 crop year, and the allocation of labor time among crops. In addition, the allocation of labor time between farm and other economic activities performed in the household is discussed.

In this connection, one should recall that small-farm households in the Zairian Basin solely rely on labor provided by household members to carry out economic, domestic, and sociocultural activities. Economic activities are made up of farm and nonfarm activities (such as hunting, fishing, and gathering). Most of these are food-producing activities.

Calendar of Farm Operations and Monthly Intensity of Labor Use

A number of farm-level studies have shown that labor shortages, particularly during peak periods, constitute one of the major constraints to food and agricultural production in most parts of Sub-Saharan Africa (Eicher and Baker 1982; Delgado 1982; Norman 1973b). For this reason the sequences of farm operations as performed by farmers in the area are presented, and attempts are made to verify whether labor shortages are experienced during peak production periods in the Zairian Basin.

The official agricultural calendar of farm operations for the area, based on research conducted at the Institut National pour l'Etude Agronomique du Congo (INEAC)⁸ during the colonial period, is summarized in Table 9. This calendar assumes only one crop season for maize and rice per year, although with the bimodal pattern of precipitation that exists in the area, it is agronomically possible to have one major and one minor crop for both rice and maize per year. From sowing to harvest, three months are required to produce maize and four months for rice. For cassava and plantain, only one crop can be produced a year. The official calendar, however, is not followed by all the farmers in the area.

Table 10, based on Appendix 2, Table 29, presents the agricultural calendar followed in each study community during the 1982/83 crop year. Because crops are planted in mixed stands, farm operations such as land preparation and weeding are simultaneously carried out for all crops. The sowing period, which runs from April to October, is more critical for rice and maize than for cassava and plantain. Harvesting of each crop is performed at the end of the cycle for that crop.

In all, farmers in the study area follow an agricultural calendar that is not strictly the same as the official one. The execution of some farm operations is extended beyond the recommended periods. Does this late execution of some farm operations imply that the demand for labor to carry out various household activities is high and concentrated in time? In other words, is this late execution of farm operations an indication of labor shortages in the area? Or is it merely a tendency among small farmers, partic-

⁸ The institute is now known as the Institut National d'Etude et Recherche Agronomique (INERA).

Table 9—Official calendar of farm operations in the study area

Period When Operations Are to Be Performed	Operations to Be Conducted in the New Farm Field	Operations to be Continued on Last Season's Crops
January-February	Slashing	Weeding and harvesting of cassava and plantain; marketing of rice, maize, cassava, and plantain.
March-April	Burning and clearing of the new plot of land; sowing of rice and maize; planting of cassava and plantain.	Weeding and harvesting of cassava and plantain; marketing of rice, cassava, and plantain.
May-July	Sowing of rice and maize; weeding.	Harvesting and marketing of cassava and plantain.
August-October	Harvesting of rice and maize; weeding of cassava and plantain; selection of plots for the new season.	Harvesting and marketing of cassava and plantain.
November-December	Processing and marketing of rice; weeding of cassava and plantain. The new crop season begins and farmers start clearing the forest.	Harvesting and marketing of cassava. Field will be turned to fallow.

Source: Zaire, Division Régionale de L'Agriculture, "Calendrier Agricole Approuvé pour la Sous/Région de la Tshopo," Kisangani, Zaire, 1980.

Table 10—Farmers' agricultural calendar in the study area, crop year 1982/83

Farm Operation	Turumbu Villages					
	Along Yangambi-Kisangani Road ^a	Weko and Yambaw	Along Yangambi-Isangi Road ^b	Mongandjo		Bomenge
				Bolikongo	Babendja	Bomaneh
Slashing	January-August	January-May	January-May	January-August	January-May	January-May
Burning and clearing	February-May	April-July	May-July	April-October	April-June	April-August
Sowing and planting	April-September	May-September	July-August	May-October	April-August	April-August
Weeding	May-August	July-December	August-October	August-December	August-December	July-December
Harvesting, processing, and marketing	July-December	September-December	October-December	August-December	August-December	August-December

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: This calendar includes only farm operations carried out in the ongoing crop year. Operations related to last crop season performed mainly by female members are weeding of cassava and plantain and marketing of rice and maize during the January-February period. Harvesting and marketing of cassava and plantain continue throughout the year.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

ularly those living in an area where rainfall is relatively well distributed throughout the year, to be flexible about the timing of farm operations?

The survey data summarized in Table 11 show that, for the study area as a whole, the largest amount of labor time allocated to household economic activities in a month was about 88 hours for males and 85 hours for females during the surveyed crop year, while the smallest amount of labor time spent was about 71 hours for males and 23 hours for females. In the humid tropics of Africa, 6 hours a day or 150 hours a month is generally regarded as the maximum a person can productively allocate to labor, either farming or nonfarming; therefore, it seems that, other things being the same, more time could have been devoted to both farming and nonfarming activities in the study area without encountering a labor shortage. The breakdown of labor allocation for each of the communities included in the study is given in Appendix 2, Table 30.

Seasonal Allocation of Labor Between Farming and Nonfarming Tasks

Figure 2, which is based on Appendix 2, Table 30, shows that the intensity of labor use throughout the year exhibits a clear seasonal pattern. Three distinct periods can be delineated for males and four for females. During January-February, the amount of time males allocate to farming increases and that spent on nonfarming activities declines. During the February-April period, the amount of time males allocate to farming is at its highest period. During April-December, the pattern is reversed, with nonfarming activities increasing and farming decreasing. For female members, May-July and September-December are the peak periods for farming activities. During these periods, the level of nonfarming activities performed by females goes down. During the January-May and July-September periods, however, the situation reverses in favor of nonfarming activities.

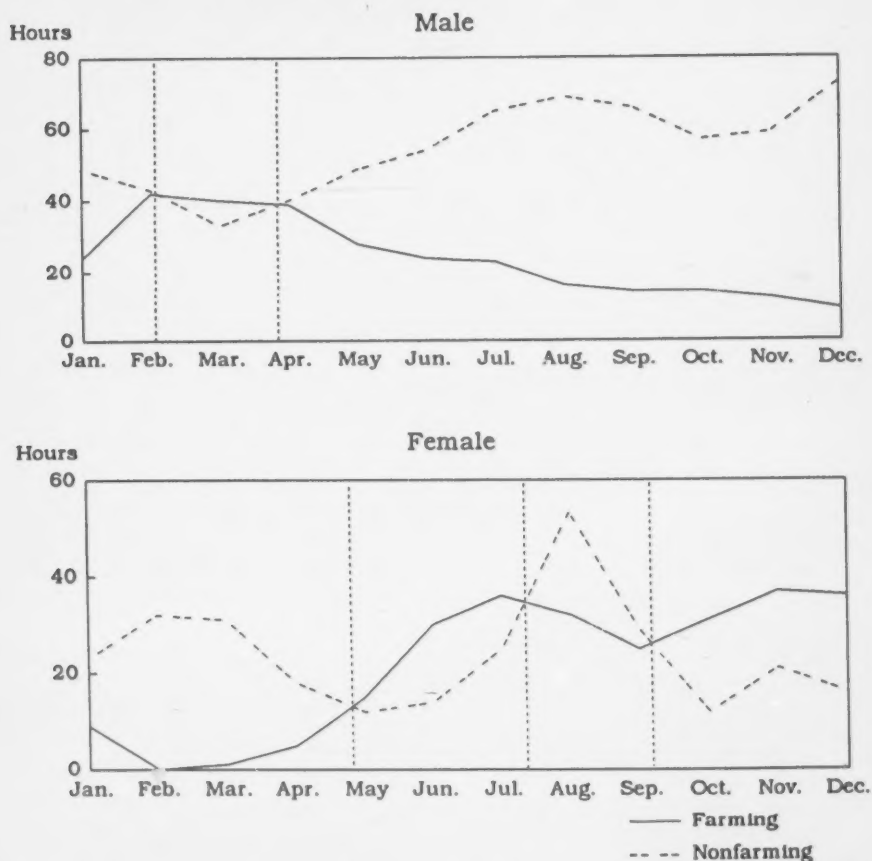
Table 11—Intensity of labor use, by month, 1982/83

Month	Economic Activities (Farming and Non- farming)		Farming		Nonfarming	
	Male	Female	Male	Female	Male	Female
	(hours/month)					
January	73	32	24	9	49	23
February	85	32	42	0	43	32
March	73	32	40	1	33	31
April	79	23	39	5	40	18
May	77	27	28	15	49	12
June	78	44	24	30	54	14
July	88	61	23	36	65	25
August	85	85	16	32	69	53
September	80	54	14	25	66	29
October	71	43	14	31	57	12
November	71	58	12	37	59	21
December	80	52	9	36	73	16

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: These are the average number of hours allocated to farming and nonfarming economic activities by a household member of either gender regardless of age. They should not be regarded as man-hours. Nonfarming activities referred to are hunting, fishing, and gathering.

Figure 2—Intensity of male and female labor use, farming and nonfarming activities, by month, 1982/83



Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

In short, the demand for labor during farming peak periods is met by substituting farming work for nonfarming, rather than by reducing leisure.

Because of the division of labor, the allocation of labor time presents different seasonal patterns for men and women. The time allocated to farming by males is large from January to May, when land preparation is mostly performed. During this period, very little time is devoted to farming by females. The reverse occurs during the period from June to December, when farm operations such as planting, weeding, harvesting, and farm-level processing are performed.

Survey data indicate that high energy-consuming farm operations such as forest slashing, burning, and clearing are almost entirely carried out by men. Less risky, low energy-consuming operations such as planting, weeding, harvesting, processing, and marketing are mainly performed by women, with substantial help from male members. This division of farm operations between men and women is consistent with biological considerations.

The area does not appear to suffer from the seasonal labor shortages that are characteristic of subhumid and semiarid areas of Sub-Saharan Africa. The distribution of rainfall, which is mostly responsible for seasonal labor shortages elsewhere in the Sub-Saharan region is not a factor here. Key factors that affect the allocation of household labor time to farming in the Zairian Basin still have to be identified.

Allocation of Agricultural Labor

Allocation Among Food Crops

Labor input allocated by each member of the household to farm and nonfarm economic activities was recorded four times a week during the one-year field survey. A number of points regarding the allocation of labor among food crops in different communities in the study area can be made based on these data (see Table 12).

In Turumbu and Mongandjo, where rice-growing has a long history, a large share of labor time was allocated to rice during the 1982/83 crop year. Seven times more labor was expended on rice than on maize in Mongandjo and twice as much in Turumbu. Because rice was only recently introduced in Bomaneh, it claimed a relatively small share of the labor allocated to farming, but its labor share was still much larger than that of plantain. A substantial amount of labor time was spent on cassava in all three communities. This allocation of labor to cassava, the main staple food crop in the area, is revealing in terms of concerns about household food security.

Table 12 also shows substantial inter- and intracommunity variability in labor allocation among crops, which has been ascribed earlier to differences in local market conditions and the degree of access to major centers. For the study area as a whole, rice, the major cash crop, claimed slightly more labor than cassava and two-and-a-half times more labor than maize and plantain combined.

Allocation of Labor to Farming

First, regarding the allocation of labor to farming (Table 13), the total labor time spent on economic activities per man-equivalent varied between 449 and 1,292 man-hours per year, with an average of 776 man-hours for the study area as a whole. Since it has already been established that as many as 1,800 man-hours a year can productively be allocated to economic activities per man-equivalent in the humid tropics of Africa, it can be said that the labor input allocated to economic activities in the area is rather low, representing on average 43.1 percent of potential productive labor time. This suggests that the area is still at a low level of economic development and that the economic activities carried out are mainly for subsistence purposes.

Second, the data show that in most villages, farming is second to nonfarming, except in the Turumbu villages along the Yangambi-Isangi road, where productive labor time was almost equally allocated to farming and nonfarming. Overall, the share of farming in total labor time spent on economic activities during the 1982/83 crop year varied between 27.3 and 55.5 percent among villages, giving an average of about 34.9 percent for the area as a whole.

Table 12—Household labor allocations to rice, maize, cassava, and plantain

Rural Community	Number of Households	Labor Allocated to Farming ^a	Rice	Maize	Cassava	Plantain
		(man-hours)			(percent)	
Turumbu	53	844 (469)	41.52	21.98	31.61	4.88
Yangambi-Kisangani road ^b	17	712 (491)	27.29	29.60	35.06	8.05
Weko and Yambaw	17	954 (512)	57.47	13.55	26.73	2.25
Yangambi-Isangi road ^c	19	864 (401)	38.25	23.50	33.43	4.82
Mongandjo	53	954 (351)	49.30	7.36	43.14	0.20
Bolikango	25	1,086 (435)	45.84	7.69	46.29	0.18
Babenga	28	837 (198)	53.14	7.06	39.58	0.22
Bomenge Bomaneh	26	519 (321)	18.36	25.62	54.87	1.15
Study area	132	824 (426)	42.52	15.09	40.40	1.99

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Figures in parentheses are standard deviations.

^a The hours devoted to farming by each member of the household were converted into man-hour equivalents using Collinson's conversion factors reported in Appendix 1.

^b These villages were located up to 22 kilometers from Yangambi.

^c These villages were located up to 20 kilometers from Yangambi.

Third, during the 1982/83 crop year, an average of 271 man-hours per man-equivalent were devoted to agriculture. This limited amount of labor input allocated to farming should not be seen as a consequence of relying on a rainfed agricultural system, where the distribution of rainfall imposes the pattern of labor use and allocation to farming. The distribution of rainfall in the Zairian Basin allows for farming all year round. A comparison with other developing areas indicates that the amount of labor input allocated to farming per man-equivalent in the study area is small even by African standards.

In a review of the literature on labor use in Africa, Eicher and Baker (1982) wrote

Farm level surveys throughout Sub-Saharan Africa have consistently shown that farmers have low annual labor inputs in agricultural production by international standards. Cleave (1974) reviewed 50 micro-level studies in countries of both high and low man-land ratios and found that male adults were working an average of 1,000 hours per year in agricultural production as compared with 2,500 to 3,000 hours per year in Egypt and many Asian countries. Some researchers have reported even fewer hours spent on farming activities, as low as 500 to 600 hours per year (Haswell 1953; Norman 1972).

The survey clearly indicates that farming is not the leading economic activity in the area. Hunting, fishing, and gathering are more important. They claimed about

Table 13—Allocation of household productive labor time between farming and nonfarm economic activities, 1982/83

Rural Community	Number of Households	Average Number of Man-Equivalents/ Household	Labor Allocated to Economic Activities/ Household		Labor Allocated to Economic Activities/ Man-Equivalent		Labor Allocated to Farming/ Man-Equivalent		Labor Allocated to Nonfarm Economic Activities/ Man-Equivalent	
			(man-hours)	(percent)	(man-hours)	(percent)	(man-hours)	(percent)	(man-hours)	(percent)
Turumbu	53	3.88 (1.53)	2,279 (1,239)	587	217	36.97	370	63.03		
Yangambi-Kisangani road ^a	17	4.24 (1.69)	2,593 (1,326)	612	168	27.45	444	72.55		
Weko and Yambaw	17	3.99 (1.49)	2,776 (1,366)	696	239	34.34	457	65.66		
Yangambi-Isangi road ^b	19	3.46 (1.38)	1,552 (576)	449	249	55.46	200	44.54		
Mongandjo	53	2.52 (0.92)	2,747 (1,250)	1,090	379	34.77	711	65.23		
Bolikango	25	2.68 (1.05)	2,395 (928)	894	405	45.30	489	54.70		
Babendja	28	2.37 (0.77)	3,062 (1,423)	1,292	353	27.32	939	72.68		
Bomenga	26	2.38 (0.73)	1,734 (716)	729	218	29.90	511	70.10		
Bomaneh	26	2.38 (0.73)	1,734 (716)	729	218	29.90	511	70.10		
Study area	132	3.04	2,359 (1,212)	776	271	34.92	505	65.08		

Source: Based on data from Tshikala B. Tshitbaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Household members were converted into man-equivalents to take account of age and sex using conversion factors derived from Collinson (1972) (see Appendix 1). Economic activities include farming and nonfarming activities (namely hunting, fishing, and gathering). Figures in parentheses are standard deviations.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

65.08 percent of the labor time allocated to economic activities during the 1982/83 year. A survey conducted in 1974/75 on a small sample of 17 households in Yalibwa, Turumbu Community, revealed that the contribution of hunting, fishing, and gathering activities to household cash income was larger than that of farming. These activities contributed about 54 percent of cash income as opposed to 36 percent from farm products. Handicraft and alcohol production shared 2 percent and 6 percent respectively (Kilumba 1975). Although it can generally be observed that the overall time allocated to economic activities in the study area is low, an assessment of key determinants of labor allocation between activities carried out in the household is beyond the scope of this study, which focuses on farming. A detailed appraisal of household labor use would warrant an entire study by itself.

Determinants of Labor Allocation to Farming

Having established that labor input per man-equivalent is low, a model is devised to identify key factors that affect the allocation of labor to farming in order to assess the implications for labor productivity and to examine policy actions that the government of Zaire should initiate to address this issue. From this exercise, implications for other key parameters such as cultivated land area, farm output, and resource productivity are derived.

Model

As stated earlier, the rural small-farm economy includes farming and nonfarming activities. These two groups of activities compete for the labor time of the household. One can then assume that the amount of labor time allocated to farming per man-equivalent is a function of the domestic terms of trade between farming and nonfarming activities. The amount of capital input available per man-equivalent and the degree of dependency also affect the amount of labor time allocated to farming per man-equivalent.⁹ This formulation also should include a dummy variable for locational and other differences among study communities and an error term.

Formally, one can express this relationship as follows:

$$L/W = f(P_1/P_2, K/W, C/W, D, e), \quad (1)$$

where

L/W = the amount of labor time in man-hours allocated to farming per man-equivalent,

P_1/P_2 = farmgate terms of trade between household agricultural and nonagricultural activities during the preplanting period,

K/W = capital input (in zaires) allocated to farming per man-equivalent,

C/W = degree of dependency expressed as a ratio of the number of household consuming units over

⁹ This chapter deals with resource allocation (of labor) within the small-farm economy. Analysis of the resource flow between smallholder and other components of the national economy, although important, is beyond the scope of the present effort.

the number of man-equivalents,¹⁰

D = dummy for location, and

e = the error term.

It is expected that

$$[\partial(L/W)/\partial(P_1/P_2)] \geq 0; [\partial(L/W)/\partial(K/W)] \geq 0; \text{ and } [\partial(L/W)/\partial(C/W)] \geq 0. \quad (2)$$

This implies that a positive change in the farmgate terms of trade between farm and nonfarm activities, capital input per man-equivalent, and degree of dependency will be associated with a positive change in the amount of labor time allocated to farming per man-equivalent.

Definition of Explanatory Variables

The main ingredients of the expression depicting the amount of labor input allocated to agriculture are capital input and the farmgate price of farm relative to nonfarm commodities produced in the households, and their degree of dependency. In this study, the preplanting farmgate prices for rice, cassava, maize, plantain, and nonfarm products (such as game meat and fish) are taken to be the relevant producer prices that affect labor allocation between household agricultural and nonagricultural activities. For each sampled household, the average preplanting price for the above crops is computed, using each crop's share of labor time allocated to farming as a weight. The price for game meat was considered for Turumbu and Mongandjo Communities, whereas in Bomaneh (Bomenge Community), the price for fish was taken. In the first two communities, hunting is the most important household nonfarm activity, whereas in the last community, fishing is. Appendix 2, Table 31, summarizes the price data.

In this study, the degree of dependency is defined as a ratio of the number of household consuming units over the number of household man-equivalents in order to relate the household food requirements to the size of the household labor force.

Regression Results

A least squares method applied to the survey data gives the regression results summarized in Table 14.

For labor allocated to farming, the regression equation indicates that the fit is fair, and the F-statistic is highly significant at the 1 percent level. The coefficients for both the preplanting farmgate terms of trade between farm and nonfarm activities (P_1/P_2) and the amount of capital input per man-equivalent (K/W) are positive and significantly different from zero, implying that these variables are key determinants of the amount of labor time allocated to farming per man-equivalent (L/W) in the Zairian Basin. The degree of dependency (C/W), introduced in the analysis on the assumption that large household size would also generate pressure to produce more foodcrops, does not explain the amount of labor time allocated to farming. Locational differences among study communities on labor allocation to agriculture are significant.

¹⁰ One consuming unit represents the food consumption of one adult male. The number of household consuming units expresses the household food requirements, whereas the number of man-equivalents, sometimes called working units, represents the available household labor force. The conversion factors proposed by Collinson (1972) to transform household members into consuming units are reported in Appendix 1.

Table 14—Determinants of labor allocated to farming, 1982/83

Explanatory Variables and Important Statistics	Dependent Variable
	Ln(L/W)
Intercept	5.62 (12.42)**
Ln(P ₁ /P ₂)	0.38 (2.70)**
Ln(K/W)	0.28 (4.58)**
Ln(C/W)	0.12 (0.66)
Dummies for location	
D ₁	-0.39 (-2.35)*
D ₃	-0.35 (-1.72)
D ₄	-0.38 (-1.44)
D ₅	-0.26 (-1.36)
D ₆	-1.06** (-4.42)
R ²	0.45
F	14.30
n	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The numbers in parentheses are t-values. Ln(P₁/P₂) is the terms of trade between agricultural and nonagricultural activities, Ln(K/W) is capital input allocated to farming per man-equivalent, and Ln(C/W) is the degree of dependency.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The elasticity estimate of agricultural labor time per man-equivalent with respect to the preplanting farmgate terms of trade is 0.38 and that with respect to capital input per man-equivalent is 0.28. This suggests that a 1.00 percent increase in the preplanting farmgate terms of trade between farming and nonfarming activities will be associated with an increase of about 0.38 percent in labor time allocated to farming per man-equivalent, whereas a 1.00 percent increase in capital input available per man-equivalent will lead to about a 0.28 percent increase in labor time allocated to agriculture per man-equivalent.

These findings suggest that appropriate policy actions to improve both the domestic terms of trade of farm products and the content of capital input (tools, equipments, seeds, fertilizers, and so on) for smallholders need to be considered if farmers are to divert more of their labor time to farming. These policies include infrastructure development and technology policies.

Given the paramount importance of labor in Zaire, an in-depth analysis of this issue is fundamental to understanding how the small-farm sector works and its level of performance. In addition, an assessment of factors that determine the amount of labor allocated to farming will contribute to understanding at least indirectly the workings

of the nonagricultural sector of the rural economy. This alone would clarify the interaction of the two sectors and help the government to formulate appropriate policies. Although the foregoing section of this chapter has identified some key variables affecting the allocation of labor to farming, a detailed appraisal of labor use in the rural economy, with all its related aspects and implications, deserves an entire study, which should logically succeed this piece of work.

RELATIONSHIPS BETWEEN LABOR, CAPITAL, AND CULTIVATED AREA

This chapter estimates the intensities of labor and capital use, identifies their key determinants, establishes the relationship between cultivated area, labor, and capital, and finally relates the above to the observed pattern of labor allocation to farming in the study area. The estimates of the structural parameters derived from this analysis are relevant for policymaking.

Intensity of Labor Use

The estimates of the intensity of labor use by crop reported in Table 15 show that rice is the most labor-consuming crop in the production mix. It is followed by cassava and then maize, while plantain is the most labor saving. Taking the labor per hectare allocated to plantain as a numéraire, one can see that rice requires about 2.95 times more labor than plantain, cassava about 2.21 times, and maize about 1.75 times. For all the crops combined, an average labor input of about 1,230 man-hours per hectare was recorded during the 1982/83 crop year, with a range of 525 man-hours per hectare for plantain and 1,547 man-hours for rice.

This intensity of labor use is high compared with other parts of the developing world, and this becomes even more disturbing in an area characterized by low population density like the Zairian Basin. For example, Lassiter (1982) reported 822 man-hours per hectare in the production of sorghum in Eastern Burkina Faso, and in the Mumbwa area of Zambia, farmers spent 568 man-hours per hectare in the production of maize (Dodge 1977). In Maharashtra State, India, 477 man-hours per hectare were allocated to traditional varieties of sorghum, whereas in Bangladesh, the production of local varieties of aman rice claimed about 1,067 man-hours per hectare (Mellor and Ranade 1986; Hossain 1988).

This high labor intensity is partly explained by high labor requirements for land preparation in the forest zone. This situation is further exacerbated by the use of hand tools and by the hot, humid tropical weather conditions, which increase the difficulty of farming. To these environmental constraints, the amount of labor time allocated to land preparation (slashing, burning, and clearing), which determines the size of cultivated area, seems to be an additional factor explaining high overall labor use per hectare. This is understandable in the sense that if a small amount of labor input is devoted to land preparation, the cultivated area will also be small. Therefore, to produce the highest possible output, relatively more labor input has to be spent on subsequent farm operations, including planting, weeding, harvesting, and farm-level processing. The overall labor use per hectare becomes much higher than it would be otherwise.

Data relating household labor and the size of cultivated area are summarized in Table 16, showing that during 1982/83, about 81.1 percent of the sampled households had a cultivated area that did not exceed 1.0 hectare per household. The rest of the households in the sample, 18.9 percent, had cultivated area greater than 1.00 hectare per household. For the sample as a whole, the average amount of cultivated area per household was 0.67 hectare with a minimum area of 0.05 hectare and a maximum

Table 15—Intensity of labor use, by crop, 1982/83

Crop	Number of Households	Average Area/ Household	Average Labor Input/ Household	Labor Intensity
		(hectare)	(man-hours)	(man-hours/hectare)
Rice	80	0.36	557	1,547
Maize	82	0.19	175	921
Cassava	128	0.29	336	1,159
Plantain	52	0.08	42	525
All crops	132	0.67	824	1,230

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

area of 2.99 hectares per household. If farm households are to be described by the size of cultivated land area, one would say, like Sen (1964), that the study area is made up of very small and small farms. As will be shown later in this chapter, this qualification of farm households based on cultivated area is critical in explaining the patterns of labor and capital use per hectare across farm households.

It is also important to note that the size of cultivated area per household varies enormously relative to the number of man-equivalents per household. The minimum and maximum numbers of man-equivalents per household recorded during the 1982/83 survey were 1.17 and 8.01 respectively with an average of 3.03 man-equivalents per household for the study area as a whole. In addition, the data show that the participation of household members in farming increased with the cultivated land area, but the variation is small relative to variation in cultivated area. This explains the observed pattern of declining labor input per hectare with increasing cultivated land area. Norman (1973b) in his study of farming among the Hausa in northern Nigeria found the same relationship but failed to explore the reasons behind this phenomenon in the Nigerian context. This inverse relationship between per hectare labor input and size of cultivated area has been extensively documented in many Asian and Latin American countries (Booth and Sundhrum 1985).

A close look at Table 16 reveals that the intensity of labor input allocated to land preparation exhibits an inverse relationship to the size of cultivated area. This finding is not anticipated: one would expect the per hectare labor input devoted to land preparation not to be affected by size of cultivated area. One explanation could be a deterioration in the quality of land preparation as larger areas are cultivated.

In addition to the size of cultivated land area, the intensities of labor allocated to land preparation and to subsequent farm operations are also expected to be affected by the length of the fallow period and by the type of crop mix adopted. To capture the effect of the length of the fallow period on the amount of labor time per hectare allocated to land preparation, a dummy variable with a value of one is assigned for a fallow period equal to or greater than seven years; otherwise, zero is assigned. The use of seven years as a benchmark is supported by agricultural research indicating that a minimum fallow period of seven years is necessary to maintain soil fertility in the humid tropics under a traditional farming system (Greenland and Okigbo 1983; Jurion and Henry 1967).

To account for the effects of the crop mix on the intensity of labor input allocated to subsequent farm operations, the share of cassava in cultivated land area is introduced

Table 16—Cultivated area and intensity of labor inputs, 1982/83

Cultivated Area (hectares)	Number of Households (percent)	Average Household Size (man-equivalents)	Area per Household (hectares)	Labor Input for All Farm Operations/ Household	Labor Input for Land Preparation/ Household	Labor Input Other Farm Operations/ Household	Labor Intensity		
							All Farm Operations	Land Preparation	Other Farm Operations
				(man-hours)	(man-hours)		(man-hours/hectare)		
0.25 or less	12.88	2.83	0.19	442.72	181.71	261.01	2,330.11	956.37	1,373.74
0.26-0.50	24.24	3.01	0.38	617.87	279.08	338.79	1,625.97	734.42	891.55
0.51-0.75	29.55	2.97	0.62	805.23	302.07	503.16	1,298.76	487.21	811.55
0.76-1.00	14.39	3.01	0.86	996.50	407.48	589.02	1,158.72	473.81	684.91
More than 1.00	18.94	3.35	1.32	1,247.57	403.85	843.71	945.12	305.95	639.17
Study area	100.00	3.04	0.67	824.42	315.44	508.98	1,230.48	470.81	759.67

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zaïrian Basin, Zaïre, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaïre, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

into the equation. The use of cassava's area share is supported by the fact that small farming in the study area is a cassava-based system, as indicated by the number of households producing this crop. Locational and other differences among study communities are taken into account through a dummy variable. And finally, the intensity of the overall labor input allocated to farming is also related to all these variables.

The regression results depicting these relationships are summarized in Table 17. The analysis shows that locational differences are significant. The regression coefficients for the dummy representing the fallow period display the expected sign, but are not significantly different from zero. This implies that the length of the fallow period does not significantly affect the intensity of labor input allocated to land preparation or to farming as a whole.

The type of crop mix does not explain the intensity of labor input allocated to all the farm operations combined, but it is an important determinant of the intensity of labor input allocated to planting, weeding, harvesting,¹ and farm-level processing. Because the share of cassava is used to express the type of crop mix, this finding indicates that the intensity of labor spent on these farm operations declines as the share of cassava in the cultivated area increases. Specifically, a 1.00 percent increase in the share of cassava leads to a decline of about 0.29 percent in the amount of time per hectare spent on planting, weeding, harvesting, and on-farm processing.

As expected, the coefficient for cultivated area is negative and highly significant in all cases. The elasticities of labor input allocated to land preparation per hectare and to other farm operations with respect to cultivated area are -0.58 and -0.26, respectively, while the estimate of the elasticity of the per hectare labor input allocated to all farm operations combined with respect to the same explanatory variable amounts to -0.42. This implies that a 1.00 percent increase in cultivated area leads to a 0.42 percent decline in intensity of labor input devoted to farming. These findings confirm what has been observed elsewhere in Asia and Latin America.

Intensity of Capital Use

The analysis of capital input data by crops indicates that rice is the most capital-consuming crop in the survey area. By taking the intensity of capital input use for plantain as a numéraire, it can be seen that 1 hectare of rice uses 6.29 times the capital input of plantain, whereas maize uses 3.48 times and cassava 3.42 times more inputs than plantain (Table 18).

The analysis of the same capital input data in relation to the size of cultivated area in Table 19 indicates that the amount of capital (tools and seeds combined) per hectare declines as the size of cultivated area increases. The disaggregation of capital input into tools and seeds gives a different picture. The amount of tools per hectare allocated to farming continues to exhibit an inverse relationship with the size of cultivated area, whereas the amount of seed shows a positive relationship.

In addition to the size of cultivated area, the intensity of capital input is also determined by the type of crop mix adopted. Locational and other differences among study communities are also expected to affect the intensity of capital use. These factors are incorporated in the analysis reported in Table 20. The regression coefficient for the type of crop mix is negative and significantly different from zero at the 1.00 percent level except for the intensity of tool use. The elasticities for the intensity of capital input (tools and seeds) and input of seeds with respect to the type of crop mix are about -0.50 and -1.65 which implies that a 1.00 percent increase in the share of

Table 17—Determinants of the intensity of labor input

Explanatory Variables and Important Statistics	Intensity of Labor Allocated to Farming	Intensity of Labor Allocated to Land Preparation	Intensity of Labor Allocated to Other Farm Operations
Ln (man-hours/hectare)			
Intercept	6.81 (17.17)**	5.35 (51.01)**	6.00 (38.00)**
Ln cultivated area	-0.42 (-7.04)**	-0.58 (-9.14)**	-0.26 (-3.37)**
Ln type of crop mix	-0.07 (-0.67)	...	-0.29 (-2.13)*
Dummy for fallow period	0.0 ^a (0.51)	0.04 (0.48)	...
Dummies for location			
D ₁	0.09 (0.74)	0.65 (4.63)**	-0.64 (-3.88)**
D ₂	0.56 (3.46)**	0.74 (5.02)**	0.23 (1.15)
D ₃	0.40 (3.36)**	0.48 (3.33)**	0.34 (2.29)*
D ₄	0.57 (4.93)**	0.79 (5.64)**	0.46 (3.30)**
D ₅	0.34 (3.17)**	0.38 (2.96)**	0.32 (2.35)*
R ²	0.42	0.48	0.33
F	12.84	18.43	10.24
n	132	132	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 18—Intensity of capital input use by crop

Crop	Number of Households	Average Area/ Household	Average Capital Input/ Household	Intensity of Capital Use
		(hectare)		(Z)
Rice	80	0.36	77.61	215.58
Maize	82	0.19	22.65	119.21
Cassava	128	0.29	33.97	117.14
Plantain	52	0.08	2.74	34.25
All crops	132	0.67	100.74	150.36

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The capital inputs here are seeds and tools combined.

Table 19—Cultivated area and intensity of capital input

Cultivated Area (hectares)	Number of Households (percent)	Average Household Size (man- equivalents)	Area/ Household (hectares)	Capital Input/Household			Capital Intensity		
				Capital Input (Tools and Seeds)	Tools	Seeds	Capital Input (Tools and Seeds)	Tools	Seeds
				(£)	(£)	(£/hectare)			
0.25 or less	12.88	2.83	0.19	52.70	49.38	3.32	277.36	259.89	17.47
0.25-0.50	24.24	3.01	0.38	68.44	58.16	10.27	180.08	153.05	27.03
0.51-0.75	29.55	2.97	0.62	104.42	82.71	21.71	168.41	133.40	35.01
0.76-1.00	14.30	3.01	0.86	95.50	70.69	24.81	111.05	82.20	28.85
More than 1.00	18.94	3.35	1.32	173.03	107.35	65.58	131.09	81.33	49.76
Study area	100.00	3.04	0.67	100.74	75.40	25.34	150.36	37.82	112.54

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zaïrian Basin, Zaïre, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaïre, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Table 20—Regression results for determinants of the intensity of capital input

Explanatory Variables and Important Statistics	Intensity of Capital Input Allocated to Farming	Intensity of Tool Use for Farming	Intensity of Seed Use
	Ln (Z/hectare)		
Intercept	4.61 (23.11)**	5.26 (6.41)**	2.24 (14.18)**
Ln cultivated area	-0.42 (-4.32)**	-0.64 (-5.26)**	0.30 (3.82)**
Ln type of crop mix	-0.50 (-2.94)**	-0.17 (-0.82)	-1.65 (-11.80)**
Dummies for location			
D ₁	-1.22 (-5.89) **	-1.34 (-5.20)**	-1.36 (-7.86)**
D ₂	-1.19 (-4.78)**	-1.06 (-3.39)**	-1.50 (-7.79)**
D ₃	-0.73 (-3.76)**	-0.81 (-3.38)**	-1.07 (-6.90)**
D ₄	-0.06 (-0.35)	-0.20 (-0.93)	0.61 (4.55)**
D ₅	0.13 (0.75)	-0.20 (-0.94)	0.24 (1.86)
R ²	0.35	0.39	0.67
F	11.08	12.56	36.95
n	132	132	123

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

cassava in the cultivated area leads to a 0.50 percent decline in the intensity of total capital input and a 1.65 percent decline in the amount of seeds used per hectare.

The coefficient for cultivated area is negative and highly significant in equations where total capital input per hectare and the cost of tools per hectare are used as dependent variables, but positive and highly significant in the equation where the cost of seeds sown per hectare is the dependent variable. The estimates of the elasticities of the intensity of capital input with respect to cultivated area are -0.42 for tools and seeds combined, -0.64 for tools alone, and 0.30 for seeds alone.

These results call for some explanation. Given that the share of tools in capital input is very large (74.9 percent on average for the study area as a whole) and given that these tools are hand held, and thus highly correlated to labor input, the intensity of capital input (tools and seeds combined) would be expected to decline as the size of cultivated area increased, as was the case for intensity of labor input. The observed positive relationship between the intensity of seeds sown and the size of cultivated area, however, suggests that households cultivating a relatively large area of land allocate relatively more land to cash crops (rice and maize) than others. In other words, farmers move from a subsistence to a market-oriented crop mix as the size of cultivated area

increases. A summary of relevant survey data supports this conclusion (Table 21). The share of cultivated area allocated to the cash crops, rice and maize, increases with the size of cultivated land area, whereas the subsistence crops, cassava and plantain, exhibit a declining trend.

An in-depth analysis of this relationship is summarized in Table 22. It shows that the share of cultivated area allocated to cash crops is linearly related not only to the size of cultivated land area, but also to the domestic terms of trade between cash and subsistence crops. The size of cultivated area, as well as the farmgate price of cash crops relative to subsistence crops, are critical variables explaining the change in the share of cultivated area allocated to cash crops by small farmers in the Zairian Basin.

A 1.00 percent increase in the size of cultivated area is associated with a 0.20 percent increase in the share of cultivated area devoted to cash crops, while a 1.00 percent increase in the domestic terms of trade between cash and subsistence crops leads to a 0.12 percent increase in the share of cultivated area allocated to cash crops.

Relationship Between Cultivated Area, Labor, and Capital

The foregoing sections have shown that expansion of cultivated area would reduce the intensities of both labor and capital use, which in turn would help increase the productivity of labor and capital inputs allocated to farming. It should also be stressed that in a situation where land is abundant relative to other resources and yield-increasing technologies are unknown, expansion of cultivated area is the main source of food and agricultural output growth. This depicts most parts of Sub-Saharan Africa and the Zairian Basin in particular, in sharp contrast with many developing areas of Asia and Latin America (Hayami and Ruttan 1985; Paulino 1986). The economic history of Zaire since 1960 suggests that the technological environment facing the small-farm sector is not going to improve in the foreseeable future unless some drastic changes in policy direction are initiated (Tshibaka 1986): therefore, expansion of cultivated area is likely to remain the key determinant of production growth.

Table 21—Cultivated area and change in crop mix

Cultivated Area	Number of Households	Average Household Size	Area/Household	Area Allocated		Share of Area Allocated	
				Cash Crops	Subsistence Crops	Cash Crops	Subsistence Crops
(hectares)	(percent)	(man-equivalents)	(hectares)	(hectare)		(percent)	
0.25 or less	12.88	2.83	0.19	0.07	0.12	37	63
0.26–0.50	24.24	3.01	0.38	0.19	0.19	50	50
0.51–0.75	29.55	2.97	0.62	0.32	0.30	52	48
0.76–1.00	14.39	3.01	0.86	0.41	0.45	48	52
More than 1.00	18.94	3.35	1.32	0.79	0.53	60	40
Study area	100.00	3.04	0.67	0.36	0.31	54	46

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Table 22—Regression results for cultivated area, farmgate prices, and share of cash-crop area

Explanatory Variables and Important Statistics	Dependent Variable Cash-Crop Area Share
Intercept	-0.42 (6.95)**
Cultivated area	0.15 (4.51)**
Farmgate price of cash crops relative to subsistence crops	0.01 (5.05)**
Dummies for location	
D ₁	-0.17 (-2.48)*
D ₃	-0.11 (-1.66)
D ₄	-0.12 (-1.92)
D ₅	-0.04 (-0.69)
R ²	0.46
F	16.87
n	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Because land is abundant and freely accessible to each household in the study area, and given the current state of technology in the area, the expansion of cultivated area depends on the amount of labor time allocated to land preparation and on the amount of capital tools available. This can be expressed as follows:

$$H = f(L_p, K_t, D, e), \quad (3)$$

where

H = the cultivated area in hectares,

L_p = the labor time allocated to land preparation in man-hours,

K_t = capital tools in zaires,

D = a dummy to account for locational and other differences among study villages, and

e = an error term.

The regression analysis was performed using Cobb-Douglas and transcendental functions. Due to serious multicollinearity between labor time allocated to land preparation and capital tools, the original data were transformed assuming a Cobb-Douglas function with constant returns to scale (Koutsoyiannis 1984). An F-test to compare the Cobb-Douglas and transcendental functional forms, derived after this transformation, suggests that the Cobb-Douglas functional form is appropriate. Table 23 displays these regression results. The fit is good and the F-statistic is significant at the 1.0 percent level. Locational differences are, overall, negligible. The coefficient for the ratio of labor to capital is positive and significantly different from zero at the 1.0 percent level.

The estimates of the elasticities of cultivated area with respect to labor time allocated to land preparation and to capital tools are 0.75 and 0.25, respectively. These elasticity estimates suggest that labor time devoted to land preparation is the most important determinant of the size of cultivated area. But one should note that the effects of capital tools used is also significant. More specifically, a 1.00 percent increase in labor time and in capital tools allocated to land preparation will be associated with a 0.75 percent and 0.25 percent increase in cultivated area respectively.

The implications for the intensities of both labor and capital use are obvious. A 1.00 percent increase in labor allocated to land preparation will ultimately lead to a 0.32 percent decline in the intensity of labor input allocated to farming.¹¹

Finally, to reduce the intensity of labor and capital use, the size of cultivated area has to be increased through greater labor time devoted to land preparation. This change in labor use and allocation will have substantial implications for the productivities of both labor and capital, which will be discussed in the next chapter. Moreover, increasing the size of cultivated area assumes that crops to be grown on this incremental area are those that can be easily marketed. The access to market, which reflects the level of infrastructural development, becomes critical. This underscores the need to improve the infrastructure in the area.

¹¹ The intensities of total agricultural labor (L) and capital (K) are related to the amount of labor time allocated to land preparation as follows: $\omega = -\theta\psi$ and $\rho = \mu\psi$, where ω and ρ stand for the elasticities of intensities of labor and capital inputs with respect to labor time allocated to land preparation; $-\theta$ and $-\mu$ stand for the elasticities of the intensities of labor and capital inputs with respect to the size of cultivated area; and finally, ψ is the elasticity of cultivated area with respect to labor time allocated to land preparation.

Table 23—Regression results for the relationship between cultivated area, labor, and input of capital (tools)

Explanatory Variables and Important Statistics	Cultivated Area/ Capital Input (Tools)
	Ln (hectare/Z)
Intercept	-5.66 (-50.44)**
Ln total labor time to land preparation/tools	0.75 (13.60)**
Dummies for location	
D ₁	-0.02 (-0.13)
D ₂	-0.37 (-1.89)
D ₃	-0.07 (-0.38)
D ₄	-0.31 (-1.96)*
D ₅	-0.07 (-0.45)
$\bar{R}^2$	0.69
F	49.16
n	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

FARM OUTPUT AND RESOURCE PRODUCTIVITIES IN THE STUDY AREA

Farm Output

Production Function

Under given technological conditions, farm output is viewed as a function of cultivated area, labor, and capital, as well as other variables such as weather. When a cross-section study is carried out in a fairly homogeneous zone, these "other" variables are regarded as given, and the farm output mainly becomes a function of cultivated area, labor, and capital.

This formulation is theoretically adequate, but since land itself is not a constraint to food and agricultural production in the Zairian Basin, the volume of farm output can be regarded as mainly determined by labor and capital inputs. In addition, because fallowing—a natural way of regenerating soil fertility—is the most important feature of the farming system in the area, the effect of the length of fallow on the level of farm output is also examined through a dummy that assumes a value of one for fallows of seven or more years, and zero for those of less than seven years (Greenland and Okigbo 1983). Furthermore, the effects of factors such as locational differences among study communities on the level of farm output are also taken into account through a dummy variable with a value of one for the community of concern and zero otherwise. Formally, this relationship can be expressed as

$$Q = f(L, K, Df, Dl, e), \quad (4)$$

where

Q = the crop output in kilograms,

L = the labor input in man-hours,

K = the capital input in zaires,

Df = the dummy for the length of
the fallow period,

Dl = the dummy for locational dif-
ferences, and

e = the error term.

An important policy variable that is included with this relationship is the period when a new crop—rice—was introduced. Rice was first introduced in Turumbu and Mongandjo during the period 1840-1911, but it was not introduced in Bomaneh until 1981/82. A dummy variable to account for the history of rice in the study area is included in the rice production function, with a value of one assumed for Turumbu and Mongandjo communities and zero for Bomaneh.

For all crops combined, the aggregate output production function includes the type of crop mix adopted as an additional shift variable. As indicated earlier, the share of the subsistence crop, cassava, in cultivated area also expresses this variable in the production function analysis.

Regression Results

Input/output data from the 1982/83 survey were regressed against the model developed above. Cobb-Douglas and transcendental functions were estimated. Due to serious multicollinearity between labor and capital inputs, the original data were transformed assuming a constant returns to scale Cobb-Douglas production function. An F-test comparing the Cobb-Douglas and transcendental forms showed the Cobb-Douglas to be a more appropriate transformation (Koutsoyiannis 1984).

For crops other than rice, the transformation in which the average product of capital (Q/K) was regressed against the labor/capital ratio (L/K) produced the most robust regression results. For rice, however, the transformation having the average product of labor (Q/L) and capital/labor ratio (K/L) as the main argument turned out to be best. The econometric reason for this is not immediately obvious. The most robust equation for either crop is given in Table 24. It is striking to see that in either case, however, the estimates of output elasticities remain the same (see Appendix 2, Table 32).

The analysis shows that capital relative to labor is the most important factor affecting the production of rice in the area, while labor input has a stronger impact on maize than capital. For cassava and plantain, labor is the overriding input. For all crops combined, the analysis suggests that labor is the main determinant of the farm output level. The labor share of the aggregate crop output is about 78 percent, whereas that of capital input amounts to about 22 percent. When all is said and done, however, it should be kept in mind that, even in this predominantly subsistence sector, the effects of capital cannot be ignored, although they are small relative to those of labor.

The analysis also indicates that the type of crop mix adopted is an important shift parameter of the overall household crop output, but locational differences among study communities cannot be ignored, and the length of the fallow period does not seem to affect the level of farm output. Finally, the date when an innovation—rice—is introduced in a community is an important variable. The analysis of rice input/output data indirectly suggests that delaying the introduction of improved inputs and techniques in a given area could seriously hinder agriculture in that area. Time plays a critical role in the process of technological change.

Resource Productivities

Average Products of Inputs

At the outset, one should note that the farm output per hectare (all crops combined), achieved under a cassava-based, mixed-crop, traditional farming system in the Zairian Basin, is quite substantial (Table 25).

The average products of labor and capital (expressed in cereal equivalents) and their values are higher in the production of cassava and plantain than in maize and rice, suggesting that cassava and plantain are more productive and profitable than maize and rice in the area. Furthermore, it is important to observe that the productivities of land, labor, and capital vary greatly across commodities within this relatively homogeneous area. This result is confirmed by a number of other studies conducted elsewhere in Sub-Saharan Africa. In the rain forest of Côte d'Ivoire, den Tuinder (1978) found that the returns to labor across major crops varied by a factor of one to five, and the

Table 24—Regression results for food crop production functions

Explanatory Variables and Important Statistics	Crop/Dependent Variable				
	Rice Ln Q/L	Maize Ln Q/K	Cassava Ln Q/K	Plantain Ln Q/K	All Crops Ln Q/K
Intercept	-1.06 (-2.14)*	0.60 (1.96)	2.72 (17.63)**	2.92 (12.13)**	0.93 (4.31)**
Ln L/K	...	0.63 (4.42)**	0.98 (16.11)**	0.85 (9.18)**	0.78 (11.24)**
Ln K/L	0.87 (5.38)**	...	...	...	...
Dr	2.14 (5.06)**	...	...	...	...
Df	0.21 (0.99)	-0.22 (-1.03)	0.04 (0.34)	0.12 (0.61)	0.05 (0.44)
S	...	...	...	...	0.83 (2.57)**
Dummies for location					
D ₁	0.08 (0.18)	0.73 (2.13)*	-0.58 (-2.96)**	0.41 (1.58)	0.11 (0.54)
D ₂	1.09 (3.39)**	-0.16 (-0.41)	-1.17 (-5.60)**	0.27 (0.66)	-0.78 (-3.34)**
D ₃	0.58 (1.64)	-0.07 (-0.17)	-0.24 (-1.22)	-0.10 (-0.38)	-0.25 (-1.31)
D ₄	0.01 (0.05)	-0.52 (-1.55)	0.65 (3.60)**	...	0.53 (3.06)
D ₅	...	-0.09 (-0.25)	0.61 (3.91)**	...	0.34 (2.22)*
R ²	0.41	0.45	0.75	0.74	0.63
F	8.81	8.71	54.43	29.17	28.14
n	80	82	128	52	132
Elasticities with respect to					
L	0.13	0.63	0.98	0.85	0.78
K	0.87	0.37	0.02	0.15	0.22

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Dr is the dummy for the date of introduction of rice in the study communities, Df the dummy for the length of the fallow period, and S the cassava share of the cultivated area to represent the type of crop mix. Output for all crops combined is expressed in kilograms of cereal-equivalents using the following conversion factors: 1.00 for maize-grains, 0.60 for paddy rice, 0.303 for cassava, and 0.220 for plantain; t-values are in parentheses. Because rice, compared with other crops, requires relatively more capital than labor, the transformation of data was performed using labor as a deflator (L). For other crops and all crops combined, which happen to require more labor than capital compared with rice, the transformation was made using capital as a deflator (K). The use of capital as a deflator in the rice equation and labor in other crop equations give the regression coefficients for the labor/capital ratio (Ln L/K) in the rice equation and capital/labor ratios (Ln K/L) in all other equations that are not statistically different from zero except in the case of maize. All the estimates of the critical parameters, for example, the elasticities, are the same regardless of the deflator used (see Appendix 2, Table 32).

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 25—Resource use and productivities in the study area

Item	Rice	Maize	Cassava	Plantain	All Crops
Resource use and output					
Distribution of crops among households	80	82	128	52	132
Cultivated area (hectare)	0.36	0.19	0.29	0.08	0.67
Labor (man-hours)	557	175	336	42	824
Capital (Z)	77.61	22.65	33.97	2.74	100.74
Output (kilograms of cereal-equivalents)	324.66	213.07	2,225.14	133.20	2,539.31
Share of each crop in total output (percent)	7.75	5.21	84.97	2.07	100.00
Average products of resources and their values					
Crop yield (kilograms of cereal-equivalents/hectare)	901.83	1,121.42	7,672.90	1,665.00	3,790.00
Value of crop yield (Z/hectare)	5,576.32	11,875.84	24,563.41	9,762.95	11,714.55
Average product of labor (kilograms of cereal-equivalents/man-hour)	0.58	1.22	6.62	3.17	3.08
Value of average product of labor (Z/man-hour)	3.60	12.92	21.19	18.58	9.52
Average product of capital (kilograms of cereal-equivalents/Z)	4.18	9.41	65.50	48.61	25.21
Value of average product of capital (Zaires/Z)	25.85	99.65	209.69	285.03	98.30
Marginal products of resources and their values					
Marginal product of labor (kilograms of cereal-equivalents/man-hour)	0.08	0.77	6.49	2.69	2.40
Value of marginal product of labor (Z/man-hour)	0.50	8.15	20.76	15.76	9.74
Marginal product of capital (kilograms of cereal-equivalents/Z)	3.64	3.48	1.31	7.29	5.55
Value of marginal product of capital (Zaires/Z)	22.49	36.85	4.19	42.72	35.57

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: The outputs of individual crops are converted into cereal-equivalents using the following conversion factors: 1.00 for maize-grains, 0.60 for paddy rice, 0.303 for cassava, and 0.220 for plantain. The estimates for individual crops and for all the crops combined are based on weighted sample sizes. In addition, since most maize output in the study area is used for the production of a local beverage, the value of average product of maize in production of the drink, which is about Z10.59 per kilogram of maize, is used as the "implicit" price of maize. The average product of maize in the production of local beverage as about 1.05 liter per kilogram of maize, and the average price of one liter of this drink was Z10.09 during the survey. Farmgate prices used to compute values of marginal and average products of resources are reported in Appendix 2, Table 31. The marginal products of resources are computed by multiplying the average products of resources with the elasticities of output.

returns to land even more. The great variability in resource productivity across areas and within areas among crops in the Sub-Saharan region could be ascribed to differences in soil types, ecology, agricultural practices, biological nature of individual crops, physical and human capital, and so forth.

Labor productivity in the Zairian Basin is lower than in other parts of Sub-Saharan Africa, particularly in the production of cereals (Mellor, Delgado, and Blackie 1987; Mellor and Ranade 1986; Dodge 1977; Massell and Johnson 1968). This study attempts to answer the basic question of whether the observed level of labor productivity can be increased given the current state of technology and resource endowment in the area.

Increasing Labor Productivity

Smallholder agriculture in the Zairian Basin has four basic characteristics: low labor input per man-equivalent, a low capital-labor ratio, a high labor share of output, and a low average product of labor. This suggests that the small-farm sector in the Zairian Basin is still at a low stage of development (Hayami and Ruttan 1985).

The current debate in Sub-Saharan Africa is how to increase the productivity of labor and consequently agricultural income. Conceptually, increasing labor productivity involves two groups of related actions. The first group concerns actions that will prompt movement along the production curve to a point where the value of the marginal product of labor is equal to the implicit wage rate. At that level, the average product of labor maximizes the returns to labor input. The second group of actions includes those that lead to an upward shift in the farm production curve. In sum, the first group of actions takes an improvement approach, while the second defines a transformation. A combination of these actions results in a substantial increase in the labor productivity (average product) of the farm sector.

This section examines whether a movement along the production curve, given the current resource base in the study area, could result in increased labor productivity, and if so what actions need to be considered in order to achieve this goal. Put differently, it analyzes, on the basis of survey data, the effects of an increased allocation of labor to farming on the productivity of labor.

Grouping the sample households on the basis of cultivated land area, as reported in Table 26, reveals that substantial increases in labor time allocated to farming are possible and, if accomplished, would ultimately result in a tremendous increase in labor productivity. Conservatively, it is possible for all households in the area to achieve, with the current resource base, an average level of labor productivity of about 3.88 kilograms of cereal-equivalents per man-hour. This represents an increase of about 26 percent over the labor productivity of 3.08 kilograms of cereal-equivalents per man-hour attained in the study area as a whole.

This is not sufficiently brought out in most studies simply because researchers tend to estimate resource productivities computed at the mean values of the inputs for the study sample as a whole. This procedure unwittingly masks the fact that a disaggregation of the study sample indicates that a large part of the study households could be productive at a level that is compatible with their current resource base if appropriate actions were taken. This leads to the conclusion that by increasing the time spent performing land preparation and other farm operations, productivity would improve. As Chapter 5 has shown, increasing the labor allocated to farming requires that both the domestic terms of trade of farm products and the content of capital input in the farm sector be improved.

Finally, it needs to be stressed that in increasing capital content not only should the availability of tools and seeds be increased through appropriate distribution, marketing, and credit policies, but also the nature of these capital inputs should be changed. High-yielding seeds in conjunction with fertilizers and pesticides should be provided—particularly for rice and maize production. Introducing these technological changes into the production process will improve the productivity of labor and other primary inputs (Dodge 1977; Mellor and Ranade 1986; Hossain 1988).

Table 26—Allocation and productivity of labor, 1982/83

Cultivated Area (hectare)	Number of Households (percent)	Available Labor Force per Household (man-equivalents)	Average Area per Household (hectares)	Labor Input to Farming		Volume of Output		Intensity of Labor Use (man-hours/hectare)	Labor Productivity (kilograms of cereal-equivalents/man-hour)
				Per Household	Per Man-Equivalent	Per Household	Per Man-Equivalent		
				(man-hours)		(kilograms of cereal-equivalents)			
0.25 or less	12.88	2.83	0.19	442.72	156.44	726.06	256.56	2,330.11	1.64
0.26-0.50	24.24	3.01	0.38	617.87	205.27	1,278.99	424.91	1,625.97	2.07
0.51-0.75	29.55	2.97	0.62	805.23	271.12	2,455.95	826.92	1,298.76	3.05
0.76-1.00	14.39	3.01	0.86	996.50	331.06	3,537.58	1,175.28	1,158.72	3.55
More than 1.00	18.94	3.35	1.32	1,247.56	372.41	4,840.53	1,444.93	945.12	3.88
Study area	100.00	3.04	0.67	824.42	271.19	2,539.21	835.27	1,230.48	3.08

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

POLICY IMPLICATIONS AND CONCLUSIONS

Resource Use and Allocation

The survey indicates that, despite ready availability of land, the cultivated area per household and the cultivated land-man ratio remain small, largely because the amount of labor time allocated to farming is limited and capital inputs are scarce. The elasticity of cultivated area with respect to labor allocated to land preparation was estimated at about 0.75 and that with respect to input of capital tools at 0.25, which suggests that the expansion of cultivated area is primarily determined by the labor time spent on land preparation and secondarily by the amount of capital tools.

According to this study, only 271 man-hours per man-equivalent were spent on farming in this zone during 1982/83—a much smaller time than has been recorded elsewhere in Sub-Saharan Africa. Cleave (1974) reported an average of 1,000 man-hours and Haswell (1953) and Norman (1972) mention 500 to 600 man-hours per man-equivalent per year. Farming's share of productive labor time was only about 35 percent; the remaining 65 percent was spent on activities such as hunting, fishing, and gathering.

The finding that a 1.00 percent increase in the preplanting farmgate price of farm products relative to nonfarm goods was associated with a 0.38 percent increase in the amount of labor allocated to farming indicates that farmers are responsive to price increases, but they perceive that other activities are more productive than farming. Another critical factor affecting the amount of labor devoted to farming in the study area is the availability of capital inputs at the household level. A 1.00 percent increase in the amount of capital input per man-equivalent allocated to farming resulted in a 0.28 percent increase in the amount of labor input devoted to farming.

Although time spent on agricultural labor is low for small farmers in the Zairian Basin, the amount of labor required to farm a hectare of land is high. For all crops combined (rice, maize, cassava, and plantain), an average labor input of about 1,230 man-hours per hectare was recorded during the 1982/83 crop year. Labor intensity ranged from 525 man-hours per hectare for plantain to 1,547 man-hours for rice. This per hectare labor use is high compared with other parts of Sub-Saharan Africa and Asia. For example, 822 man-hours of labor per hectare of sorghum were recorded in Eastern Burkina Faso and 568 man-hours per hectare of maize in the Mumbwa area of Zambia. The production of local varieties of sorghum in Maharashtra State, India, required 477 man-hours per hectare, and that of local varieties of aman rice in Bangladesh 1,067 man-hours.

The high labor input per hectare in the Zairian Basin is mostly explained by the large amount of energy consumed in land preparation with hand tools in this rain-forest area. The tropical climate saps farmers' energy and contributes to the drudgery of farming. To these environmental constraints, the relatively small amount of labor allocated to land preparation constitutes an additional hindrance. The intensity of labor use per hectare was found to be negatively related to the size of cultivated area. A 1.00 percent decrease in cultivated area is associated with a 0.42 percent increase in the per hectare labor use. Because so little land is prepared, the intensity of labor use per hectare tends to be higher. Increasing labor allocated to land preparation would

help reduce the intensity of labor use per hectare. A 1.00 percent increase in labor allocated to land preparation is associated with a 0.75 percent increase in cultivated area, which, in turn, translates into a 0.32 percent decline in the amount of labor input per hectare.

Resource Productivities

Considering the productivities of resources—that is, the average products of inputs and their values—the study shows that cassava and plantain are the most productive and profitable crops in the area. The expansion of cassava and plantain output has to be tied to the development of livestock and related industries. Without this vertical integration, the long-term prospects are not encouraging, because demand for these crops (for human consumption) tends to decline as incomes rise. Rice and maize, the two cereals produced in the area, have not been very productive, although agronomic studies conducted in the area suggest that the production of improved varieties could yield at least 2,500 and 3,000 kilograms per hectare, respectively, compared with about 900 and 1,100 kilograms per hectare at present.

Low productivity of labor in the study area, particularly in the production of cereals, is indicative of the small-farm sector in Zaire. And this is one of the key factors underlying the decrease in per capita food output that has characterized the country for the last two decades. To reverse the situation, substantial efforts to enhance the productivity of labor input have to be initiated.

Conclusions

To increase the productivity of agricultural labor in the Zairian Basin, the study suggests that efforts to stimulate farmers to allocate more labor to farming should be initiated by the Zairian Government. Since allocation of labor to farming is mostly determined by the domestic terms of trade between farm and nonfarm products and by the content of capital input available to farmers, two sets of related policy actions need to be considered.

First, the public sector should assume a larger role in efforts to integrate this remote area into the mainstream of the national economy through investment in infrastructural development such as roads and transportation systems. This integration will enhance the terms of trade of farming in the area.

Second, steps to promote the capital market and to increase farmers' access to this market through a set of policies including credit and pricing policies must be taken. Specifically, measures to establish a distribution and marketing system for tools, equipment, and seeds need to be examined in the short-to-medium term.

Furthermore, with respect to the introduction of improved rice seeds, investments in biological and chemical technologies offer opportunities to improve the productivity of labor and other primary inputs, particularly in the production of cereal crops.

Each of these policy actions is indispensable for getting agriculture moving in the area. The cost of these policy actions is important, but whether these expenditures have to be made is not a debatable issue. The Zairian Basin represents almost 40 percent of the total land mass. Investments in this region are a must if a stimulating economic environment is to be created despite the region's sparse population. The development of the farm sector alone (food and nonfood crops) will not cover the costs, but because of these investments, other economic activities will develop.

Perhaps the most important open question is that of sequencing and timing of investments in view of limited government and private resources. A detailed analysis of this issue is a necessary and useful complement to this study. Based on the findings here, however, the first actions should include maintenance of the existing road network, the development of an input delivery system for tools, equipment, and seeds, and the provision of credit. Finally, it should be stressed that the rain forest zone of Sub-Saharan Africa is more suited to tree crops than to annual food crops. Logically, therefore, the appropriate smallholder agriculture to promote in the Zairian Basin in the long run is a tree crop production system, with farm households relying largely on purchased food. But, in the short and medium terms, smallholders in the area will continue to be primarily food-producing.

It is hoped that the findings of this study will provide a guideline for policymakers to follow in designing policies to enhance the production of food crops in the short and medium terms, as well as the production of tree crops by smallholders in the long run. Although this study is concerned with a rather small part of rural Zaire, both the findings and the policy implications should have wider relevance for Zaire as a whole.

APPENDIX 1: SOME METHODOLOGICAL NOTES

Statistical Method Used in Allocating Cultivated Area Among Mixed Crops

The method formulated here was proposed by the Institut National des Statistiques et d'Etudes Economiques de France in the book entitled *La Statistique Agricole dans les Pays en voie de Développement*, as presented in Kaseko (1976).

The symbols are defined as follows:

- A and B = two crops in mixed stands,
- d_A and d_B = densities of these crops in a pure cropping system,
- d'_A and d'_B = densities of the same crops when they are mixed,
- T_A and T_B = areas effectively occupied by these crops, and
- T = total area.

Let

$$a_A = d'_A/d_A \text{ and } a_B = d'_B/d_B.$$

It is accepted that the areas occupied by A and B are proportionate to a_A and a_B respectively. It is also accepted that

$$T_A/a_A = T_B/a_B, \text{ and } T_A + T_B = T.$$

Thus,

$$T_A = T(a_A/a_A + a_B), \text{ and } T_B = T(a_B/a_A + a_B).$$

This can be generalized to include n crops in mixed stands as follows:

$$T_i = c_i T,$$

where

$$c_i = A_i / \sum_{i=1}^n a_i.$$

The coefficient, c_i , is referred to as the part of the cultivated land effectively occupied by crop i.

For the purpose of the study, pure crop densities were computed using the following crop spacings proposed by Institut National d'Etude et de la Recherche Agronomique (1971):

0.30 meter $\times$ 0.20 meter for rice,
0.75 meter $\times$ 0.50 meter for maize,
1.00 meter $\times$ 1.00 meter for cassava, and
4.00 meters $\times$ 4.00 meters for plantain.

Mixed crop densities were estimated directly from yield plots.

Yield Plot Method

Yield plots of 9 square meters each were selected for rice, a high-density crop. For maize and cassava, plots of 16 square meters and 25 square meters each were considered. Because the number of plantains in the fields was limited, a complete count was performed. The operation was spread over a long period of time during the survey for cassava and plantain, slow-maturing crops.

The yield plot method tends to overestimate actual crop yields, particularly when the fields are heterogeneous and contain mixed crops (Tollens 1975; Poate and Casley 1985). To reduce the level of this error, five plots were delimited in each household field. The number of plants in these five plots were counted. Due to variation in soil fertility, crop density, and a number of other factors, the pattern of crop yield variation within a field approximates a clustered rather than a random distribution. Therefore, at harvest time, each field was divided into four clusters. The number of plants counted in the five yield plots were randomly harvested all over each cluster; and the crop yield for the field was then derived.

This method provides an estimate of the biological rather than the economic yield because it does not account for crop losses. Nevertheless, the estimates of biological crop yields are still relevant for policy analysis. The estimation of crop losses that occur between harvest and the disposition of the crop constitutes an important research topic on its own merits.

Collinson's Conversion Factors for Man-Equivalents

In his book entitled *Farm Management in Peasant Agriculture, A Handbook for Rural Development Planning in Africa*, Collinson (1972) proposes a set of conversion factors that take age and sex into account in transforming farm household size into man-equivalents. Spencer (1972) in his rice study conducted in Sierra Leone proposes a different set of conversion factors. Norman (1973b) in his study of peasant agriculture among the Hausa in northern Nigeria suggests yet another set of conversion factors. After a critical examination of these three sets of conversion factors in the context of small farming in the Zairian Basin, Collinson's conversion factors were adopted (see Table 27). The breakdown of man-equivalents per household for the entire study area is given in Table 28.

Table 27—Collinson's conversion factors for man-equivalents

Age Group (years)	Male	Female
Less than 10	0.00	0.00
10-14	0.25	0.25
15-19	0.67	0.50
20-55	1.00	0.67
More than 55	0.67	0.50

Source: M. P. Collinson, *Farm Management in Peasant Agriculture, a Handbook for Rural Development Planning in Africa* (New York: Praeger, 1972).

Table 28—Number of man-equivalents per household in the study area

Rural Community	Number of Households	Males	Females	Total
(man-equivalents/household)				
Turumbu	53	2.19 (1.12)	1.69 (0.73)	3.88 (1.53)
Yangambi-Kisangani road ^a	17	2.47 (1.11)	1.77 (0.88)	4.24 (1.69)
Weko and Yambaw	17	2.12 (1.23)	1.87 (0.73)	3.99 (1.49)
Yangambi-Isangi road ^b	19	1.99 (1.02)	1.46 (0.56)	3.45 (1.38)
Mongandjo	53	1.29 (0.59)	1.23 (0.59)	2.52 (0.92)
Bolikango	25	1.35 (0.68)	1.33 (0.69)	2.68 (1.05)
Babendja	28	1.24 (0.50)	1.13 (0.48)	2.37 (0.77)
Bomenge	26	1.28 (0.41)	1.10 (0.56)	2.38 (1.73)
Bomaneh				
Study area	132	1.65 (0.41)	1.39 (0.69)	3.04 (1.36)

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Figures in parentheses are standard deviations. Collinson's conversion factors reported in Table 27 are used to compute man-equivalents.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

APPENDIX 2: SUPPLEMENTARY TABLES

Table 29—Agricultural calendar for study villages, 1982/83

Location/Farm Operation	J	F	M	A	M	J	J	A	S	O	N	D
Yangambi-Kisangani road^a												
Slashing	•	•	•	•	•	•	•	•				
Burning and clearing		•	•	•	•	•	•	•	•			
Planting				•	•	•	•	•	•			
Weeding					•	•	•	•	•	•	•	•
Harvesting, processing, and marketing							•	•	•	•	•	•
Weko and Yambaw												
Slashing	•	•	•	•	•	•	•	•	•			
Burning and clearing				•	•	•	•	•	•			
Planting					•	•	•	•	•	•	•	•
Weeding							•	•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Yangambi-Isangi road^b												
Slashing	•	•	•	•	•	•	•	•	•			
Burning and clearing					•	•	•	•	•			
Planting							•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing, and marketing									•	•	•	•
Bolikango												
Slashing	•	•	•	•	•	•	•	•	•	•	•	•
Burning and clearing				•	•	•	•	•	•	•	•	•
Planting					•	•	•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Babendja												
Slashing	•	•	•	•	•	•	•	•	•	•	•	•
Burning and clearing				•	•	•	•	•	•	•	•	•
Planting				•	•	•	•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Bomaneh												
Slashing	•	•	•	•	•	•	•	•	•	•	•	•
Burning and clearing				•	•	•	•	•	•	•	•	•
Planting				•	•	•	•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing and marketing								•	•	•	•	•

Notes: This calendar includes only farm operations carried out in the ongoing crop year. Operations related to last crop season performed mainly by female members are weeding of cassava and plantain, and marketing of rice and maize during the January-February period. Harvesting and marketing of cassava and plantain continue throughout the year.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

Table 30—Monthly intensity of labor allocated to farm and nonfarm activities per member household, 1982/83

Month	Turumbu Villages										(number of hours/month)				Average for Study Area	
	Along Yangambi-Kisangani Road		Weko and Yambaw		Along Yangambi-Isangani Road		Boilikango		Babendja		Bomange Bomaneh		Non-farming		Farming	
	Non-farming		Farming		Non-farming		Farming		Non-farming		Farming		Non-farming		Farming	
	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming
Males																
January	20	52	12	49	17	29	28	69	44	61	20	38	24	49	24	49
February	23	54	43	58	40	25	51	50	55	36	37	34	42	43	42	43
March	25	27	42	51	46	26	37	40	55	29	35	29	40	33	29	33
April	24	55	28	60	37	27	66	28	55	45	23	29	39	40	39	40
May	18	70	29	75	24	41	59	20	15	81	24	26	28	49	28	49
June	17	71	24	67	25	46	46	27	21	114	12	22	24	54	24	54
July	21	74	31	74	31	31	45	36	6	180	6	23	23	65	16	69
August	14	75	31	63	21	29	22	53	7	200	3	25	16	69	16	69
September	18	53	14	55	15	27	16	58	14	186	14	38	14	66	14	66
October	20	60	5	52	23	26	9	67	14	109	12	37	14	57	12	57
November	17	57	7	37	26	23	9	77	12	152	3	27	12	59	12	59
December	14	76	8	70	11	37	3	84	18	155	1	39	9	73	9	73
Females																
January	18	17	27	17	15	12	3	45	0	13	9	23	9	23	9	23
February	0	41	0	18	0	28	0	49	0	28	1	25	0	32	0	32
March	1	15	0	32	0	9	1	67	0	34	3	24	1	31	5	18
April	1	22	5	18	3	11	1	19	8	34	10	11	5	18	5	18
May	4	8	23	10	6	11	1	5	6	36	56	8	15	12	15	12
June	9	7	25	10	28	8	31	6	49	55	24	7	30	14	30	14
July	11	25	49	14	37	11	76	25	30	73	6	11	36	25	36	25
August	14	47	44	50	22	31	74	36	22	197	7	7	32	53	32	53
September	11	13	31	12	23	10	38	22	28	140	15	3	25	29	25	29
October	24	6	22	6	41	6	25	23	55	26	12	4	31	12	31	12
November	28	9	37	3	55	4	58	29	39	90	6	4	37	21	4	37
December	25	13	39	2	26	3	53	25	55	61	4	2	36	16	2	36

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: These are hours allocated to farming and nonfarming by average household member of either gender regardless of age. They should not be regarded as man-hours. Nonfarm activities refer to hunting, fishing, and gathering.

Table 31—Preplanting farmgate prices in the study area, 1982/83

Rural Community/ Farm Number	Villages	Rice Paddy	Maize	Cassava (Raw)	Plantain Bunch	All Four Crops ^a	Game Meat
(Z/kilogram)							
Turumbu							
2-16	Yalungu and Yaselia	3.65	1.10	0.59	0.78	0.87	13.04
17-23	Bosukulu	3.98	1.26	0.64	0.79	0.95	15.47
24-29	Yaondolo II and Yandimbila II	5.00	1.14	0.65	0.71	1.03	13.81
30-35	Yalolia II	5.00	1.18	0.73	0.64	1.10	15.86
36-48	Weko	3.16	1.01	0.29	0.53	0.57	18.23
49-61	Yambaw	1.78	1.04	0.25	0.40	0.43	14.19
62-76	Yakwondi and Obiloto	3.73	1.20	0.75	1.47	0.73	9.48
77-82	Lilanda	3.99	1.40	1.46	1.75	1.66	8.31
83-85	Yambeke and Yaisowa	2.91	1.24	1.26	1.64	1.39	7.52
Mongandjo							
86-105	Bolikango I and II	3.88	1.43	1.01	1.08	1.27	5.28
106-115	Bomboma	3.45	1.43	1.27	1.43	1.45	14.00 ^b
116-137	Bolima and Bokangela	2.75	1.38	1.33	2.25	1.45	13.06
138-145	Bokobangolo and Bodjonga	2.50	1.00	1.00	1.35	1.11	9.81
Bomenge							
146-175	Bomaneh	5.53	2.03	1.45	1.8	1.82	5.89 ^b
Study area							
2-195		3.67	1.27	0.91	1.19	1.12	11.71

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

^a The share of each crop in total labor input allocated to farming was used as a weight for the weighted average farmgate price for the period of September 1982 to March 1983. During the period between September and March, most of the land preparation is performed.

^b The price of fish is given instead of meat.

Table 32—Regression results for food crop production functions using capital as a deflator for rice and labor for other crops

Explanatory Variables and Important Statistics	Crop/Dependent Variable				
	Rice Ln Q/K	Maize Ln Q/L	Cassava Ln Q/L	Plantain Ln Q/L	All Crops Ln Q/L
Intercept	-1.06 (-2.14)*	0.60 (1.96)	2.72 (7.77)**	2.92 (12.13)**	0.94 (4.31)**
Ln L/K	0.13 (0.78)	...	...	...	...
Ln K/L	...	0.37 (2.64)*	0.02 (0.37)	0.15 (1.61)	0.22 (3.09)**
Dr	2.14 (5.06)**	...	...	...	...
Df	0.21 (0.99)	-0.22 (-1.03)	0.04 (0.34)	0.12 (0.61)	0.05 (0.44)
S	...	...	...	...	0.83 (2.57)**
Dummies for location					
D ₁	0.08 (0.18)	0.73 (2.13)*	-0.58 (-2.96)**	0.41 (1.58)	0.11 (0.54)
D ₂	1.09 (3.39)**	-0.16 (-0.41)	-1.17 (-5.60)**	0.27 (0.66)	-0.78 (-3.34)**
D ₃	0.58 (1.64)	-0.07 (-0.17)	-0.24 (-1.22)	-0.10 (-0.38)	-0.25 (-1.31)
D ₄	0.01 (0.05)	-0.52 (-1.55)	0.65 (3.60)**	...	0.53 (3.06)**
D ₅	...	-0.09 (-0.25)	0.61 (3.91)**	...	0.34 (2.22)*
R ²	0.42	0.26	0.56	0.04	0.53
F	9.11	5.02	23.59	1.39	19.34
n	80	82	128	52	132
Elasticity of output with respect to					
L	0.13	0.63	0.98	0.85	0.78
K	0.87	0.37	0.02	0.15	0.22

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Dr is a dummy to reflect the date of introduction of rice in different communities, Df is a dummy to account for the length of the fallow period, and S is a dummy for the share of cassava in cultivated area to reflect the effect of the crop mix adopted.

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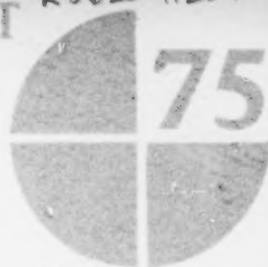
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IRRIGATION TECHNOLOGY AND COMMERCIALIZATION OF RICE IN THE GAMBIA: EFFECTS ON INCOME AND NUTRITION

Joachim von Braun
Detlev Puetz
Patrick Webb

August 1989

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FOREWORD

With its focus on irrigation technology and commercialization of rice in West Africa, this study addresses the question of how agricultural growth in Sub-Saharan Africa may improve food security. Over the last few decades in Africa, rice has ranked second after maize among cereals that have contributed to the overall growth of cereal output. In West Africa, rice imports have grown rapidly during the last two decades. Future decisions on irrigation investments and technology choices will be of critical importance in view of numerous past failures and excessive costs of irrigation in Sub-Saharan Africa.

This research by Joachim von Braun, Detlev Puetz, and Patrick Webb is to be seen against the backdrop of policy priorities resulting from the earlier work of IFPRI and its collaborators on accelerating food production in Sub-Saharan Africa.

The study results highlight the measurable positive effect that incremental income in the hands of the poorest has on nutritional improvement. It is encouraging to learn that yield levels comparable to the highest yields in Asia can be obtained in irrigation schemes in Africa, but the issue of lowering irrigation costs remains a crucial one. In part, these currently high costs are due to the general lack of infrastructure in Africa. Another emphasis of the study is the identification of very high substitution effects between irrigated crops and rainfed crops because of swift labor movements between the crops.

The study comprehensively traces the nutritional effects of technological change in The Gambia via production, income, employment, and consumption effects in innovative ways. It stresses the need to consider cause and effect relationships in complex household economic systems. Having a multidisciplinary team of economists, anthropologists, and public health experts work on these issues has proven very useful.

A particularly noteworthy aspect of this study is the complex relationship between agricultural productivity and labor utilization. An increase in labor productivity may induce both fundamental changes in the intrahousehold system of division of labor and major shifts of labor between agriculture's subsectors. Emphasis is required in program design on breaking the labor bottlenecks in this environment under seasonal stress.

Among the important lessons of the study are that technological change is a key to improving food security at the household level in this West African environment, and that irrigated rice with appropriate technological considerations in the riverine areas can make a substantial contribution. To incorporate women farmers into the technologically driven modernization process, women must have access to the means that permit them to use the new technologies—especially access to inputs and credit. Food-security improvements in terms of reduced hunger are substantial and can be cost-effective with technological change, but health and sanitation constraints in environments with weak rural health services need to be alleviated jointly to reap maximum benefits from the agricultural commercialization process. The latter point confirms findings of comparable research by IFPRI in Guatemala and Kenya that health and sanitation services in rural areas have to move in tandem with the agricultural modernization process in order to reduce the nutrition problem along with the hunger problem.

John W. Mellor

Washington, D.C.
August 1989

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SUMMARY

Technological change in African agriculture is usually necessary, but not always sufficient, to achieve sustained increases in production. How can technical progress in a crop, and the resulting local growth in marketed surpluses of that crop (that is, the commercialization of traditional agriculture), be designed and complemented so as to improve the chances of African countries to (1) raise the aggregate output of crops, and (2) reduce poverty, improve food consumption, and advance nutrition, especially among vulnerable preschoolers?

This study examines such questions in the setting of a major technical improvement in rice production in a West African country. The study asks: To what extent does technical change raise production? Does such change encourage the diversion of labor from other activities into modern rice or into leisure as income rises? If extra production does materialize, does it increase income and consumption? If so, do the poor benefit from this? Does any such extra consumption affect adult and child nutrition? The links between production, income, consumption, and nutrition are explicitly established in the analysis.

The study focuses on a new rice irrigation project involving about 7,500 farmers in The Gambia. The study site was selected because households could be traced during and after the introduction of new rice production technology (mechanical pump irrigation and improved drainage for rainfed and tidal irrigation).

The empirical research is based on a detailed sample survey of 900 farmers in 10 villages. This sample includes both participants and nonparticipants in the irrigation project and covers the four major ethnic groups of the area, thereby providing a fair degree of representativeness for a wider part of the West African region, especially major parts of Senegal and Guinea. Account is taken of the complexity of production-consumption relationships in the large households that are typical of the region.

Production in the project takes place under fully water-controlled conditions (pump irrigation and drainage) that provide two crops per year, and also under partly water-controlled conditions (tidal irrigation or improved rainfed cultivation and drainage) that provide only one crop (in the wet season). Wet season yields in the fully water-controlled perimeters were 6.6 metric tons per crop per hectare in 1984 but dropped to 5.2 tons in 1985. In the same two periods, the partly water-controlled rice yielded 2.2 and 2.8 tons, respectively. Traditional rainfed rice (predominantly a women's crop grown in swamps) yielded 1.3 tons. Great variance in costs and net returns is observed between the technologies and between individual farmers using the same technology.

Average and marginal labor productivities are assessed in the context of the production system for the major crops. Average labor productivity (net returns per labor day) was highest for rice under pump irrigation (US\$2.45), followed by coarse grains (US\$1.50), groundnuts (US\$1.45), rice in the partly water-controlled project fields (US\$1.23), and traditional swamp rice (US\$0.95).

Most farmers at the project location grow both irrigated rice and upland crops. The expansion of modern irrigation has pulled labor away from the upland crops, causing a loss of 531 calories in other crops for every 1,000 calories gained in rice production—a net gain of 47 percent.

Men's overall labor input to agriculture is reduced when the household has more land in the project. Women's labor input, on the other hand, remains more or less constant. Hired labor accounts for 25 percent of the work in the pump-irrigated plots. Since hired labor played only a marginal role in rice production before the project, this reflects an increased use of hired labor in rice as a phenomenon associated with commercialization.

There was a specific attempt in this program to ensure access to project land by women, the traditional rice producers. Formal land titles for plots were given to female farmers. Yet the results were not as planned. Women continue to control 91 percent of traditional swamp rice fields, and even 77 percent of the partly water-controlled fields, but they control only 10 percent of the pump-irrigated plots.

Less of the new rice crop is sold for cash than expected—12 percent of total production from pump irrigation and 7 percent from partly water-controlled land. This compares with women's traditionally grown swamp rice, of which 21 percent is sold. This pattern of women selling relatively more than men is explained by the different institutional arrangements under which the crops are grown. The high-technology rice in the project has largely become a communal food crop for the common household pot under the compound head's control, while women's traditional rice is a mixed private crop (partly grown for cash) and communal food crop.

Protecting and enhancing women's productive role in agriculture is an important objective in itself. It is also important as an indirect path toward nutritional improvement. The study finds, however, that this objective cannot be enforced through bureaucratic means (formal land titles), which have little relevance in the field.

Average annual per capita income in the study area was US\$116 in 1985/86; agricultural income contributed 77.5 percent. Rice production in the project contributed 43.0 percent of income to the bottom income quartile (income per adult equivalent) versus 26.0 percent to the top quartile. The poor households thus benefit relatively more than do the upper-income groups in the area. At the sample average, the rice in the project increased real incomes by 13.0 percent per household.

An additional 10.0 percent of income leads to a 9.4 percent increase in food expenditures and a 4.8 percent increase in calorie consumption. The seasonal fluctuation in per capita calorie consumption is a problem of the poor and not of the total rural population. In the bottom income quartile, calorie consumption is 15.0 percent lower in the wet (hungry) season than in the dry season, but it remains constant and, indeed, sufficient in the top quartile. In the wet season, 49.0 percent of households in the bottom quartile consumed less than 80 percent of calorie requirements; only 2.0 percent of the top quartile fell below that level.

In the wet season, 35 percent of children under five years of age and 52 percent of those aged one to two years were found to be underweight. Lack of food, unclean water, and infectious diseases are identified as important determinants of nutritional status in multivariate analyses. Mothers' nutrition and health are considerably affected by seasonal work stress.

Household-level calorie consumption is a determining factor for differences in the nutritional status of children in the study area. A 10.0 percent increase in calorie availability per capita increases the weight-for-age indicator of nutritional status by 2.4 percent at sample means. This calorie elasticity of nutritional improvement is even higher in households with higher calorie deficiencies. To the extent that the new technology increased household income, and thereby calorie consumption, and to the extent that mothers' seasonal stress was reduced, the nutritional status of children and women has improved.

The study implies a set of policy conclusions for improved technology utilization, food security, and nutrition. A more broad-based policy and program emphasis on improvements in rural infrastructure, agricultural input delivery systems, and labor-saving technology for the peak season is called for rather than a focus on a single crop.

Rice irrigation shows promising potential in the study area, but technology choice and project design issues are complex. Specific suggestions related to choice of rice production technologies demonstrate opportunities for cutting costs in the respective technologies.

Measures are proposed to protect and enhance women's productive role in agriculture; for example, women's role as cash croppers and their lack of credit require more attention.

From a food security perspective, a wide distribution of small irrigated rice plots is needed across households and village communities in the area to reduce the adverse effects of seasonality and consecutive drought years on consumption. Such scattered distribution of the highly productive irrigated land results, however, in fluctuating yields, since in years of good rainfall labor is allocated more heavily to upland farming, while in drought years labor shifts more to the irrigated fields. Thus, good rainfall years appear bad for production in irrigated farming surrounded by upland farming with large year-to-year fluctuations of labor productivity. In the absence of well-developed rural financial markets, the food-security benefit of scattered land distribution (rather than creation of larger specialized rice farms) should be an important consideration despite the instability it induces in irrigation projects and the related project management burdens.

Finally, the study suggests that efforts to solve the nutrition problem can be furthered through more effective rural health services and sanitation (that is, drinking water) at the community level. The interactions between food shortage and morbidity, which establish the high prevalence of malnutrition in this study area, cannot be dealt with effectively from the food supply side only. The nature of the nutrition problem requires a strong focus on women (mothers) rather than on young children alone.

SCOPE OF THE STUDY AND CONCEPTUAL FRAMEWORK

An increasing number of low-income countries, especially in Africa, are facing crucial strategic decisions on how to cope with short- and long-term food-security problems. At the core of these strategic decisions is the appropriate choice of policies to promote technological change and increased market integration of crop production. This choice has to be addressed both for food crops for local consumption and for food and nonfood crops for export. This study is part of a larger ongoing effort at IFPRI that is aimed at improving understanding of the effects of technological change and commercialization at the household level.¹ The objective of this research is to provide planners and policymakers with insights that will help guide program design and policies that affect the process of technological change and commercialization in traditional agriculture. With such information at hand, potentially adverse effects of change on the consumption and nutrition of the poor may be avoided and the benefits enhanced.

In a broader sense, this study, with its focus on rice and irrigation, ties in with IFPRI's research (between 1979 and 1985) on rice policy in Southeast Asia and comprehensive studies on technological change of rice in Bangladesh (Hossain 1988). It also relates directly to IFPRI's research on changing consumption and production patterns in the Sahel, that is, the relative shift away from coarse grains (Delgado and Miller 1985), and evolves out of research priorities identified in IFPRI's collaborative efforts in Africa (Mellor, Delgado, and Blackie 1987).

The main research questions of this study are (1) How do technological change and commercialization affect resource use, income, consumption, and nutrition? (2) How can programs and policies for technological change in agriculture be designed in order to enhance the positive income effects of market integration and to cope with potentially adverse welfare effects? (3) Does the process of commercialization have adverse effects on the consumption and nutrition of selected groups of households or individuals within households? and (4) How can the rural poor, especially female farmers, be effectively integrated into the commercialization process? These general questions are tailored in this study to a case study in West Africa in which groundnuts are the principal cash crop and pump-irrigated rice production is a driving force of technological change and commercialization.

A few words are in order here to define *technological change* and *commercialization*. Technological change is understood as increased aggregate factor productivity, that is, the same output produced with fewer inputs or more output produced with the same amount of inputs, though the nature and composition of the inputs may be different.

Increased commercialization may occur with or without technological change. However, technological change rarely occurs without commercialization—at least on the factor-input side of production (seed, fertilizer, irrigation, hired labor), if not on the product-output side, leading to an absolute or relative expansion of marketed surplus. It should be underscored that in considering commercialization in this setting, the

¹ Studies following a similar approach have been undertaken by IFPRI in Kenya, the Philippines, Rwanda, and Guatemala.

study is not dealing with a typical situation that involves a change in crop mix, away from food crops for home consumption toward new crops grown primarily for sale. In this instance, the project under consideration introduced new technology for improved production of a single crop (rice) that was already grown and marketed locally to a limited extent.

The project was aimed at increased output and increased market integration through technological change in rice. Various irrigation technologies were introduced, comprising different packages of inputs and degrees of water control. In this study case, technological change and increased commercialization are closely intertwined, which suggests the need to carefully address costs of production along with expansion in output.

The relationships between technological change in food production, markets, and income and the effects of such change on food consumption and nutrition are complex. The more intricate the household organization and its production arrangements, the less straightforward these relationships are. However, if the food security of the rural poor is to be effectively improved and sustained, such links need to be thoroughly understood. Furthermore, a complete assessment of the multifarious effects of technological change requires an integrated view of households and of the markets in which they interact.

This study deals with the local- and household-level effects of technological change and commercialization in rice production. An attempt is made to identify and quantify the effects of such change in the spheres of employment, time allocation, labor productivity, income, and marketed surplus, and to determine how these affect consumption and nutrition. The special characteristic of the study is that the effects of change in production and marketing are traced through to the relevant consumption and nutrition effects. Considerable research exists covering individual aspects of the chain of events depicted in Figure 1,² but so far very little empirical research has attempted to trace the interconnections of the major elements of this chain, especially in Africa.

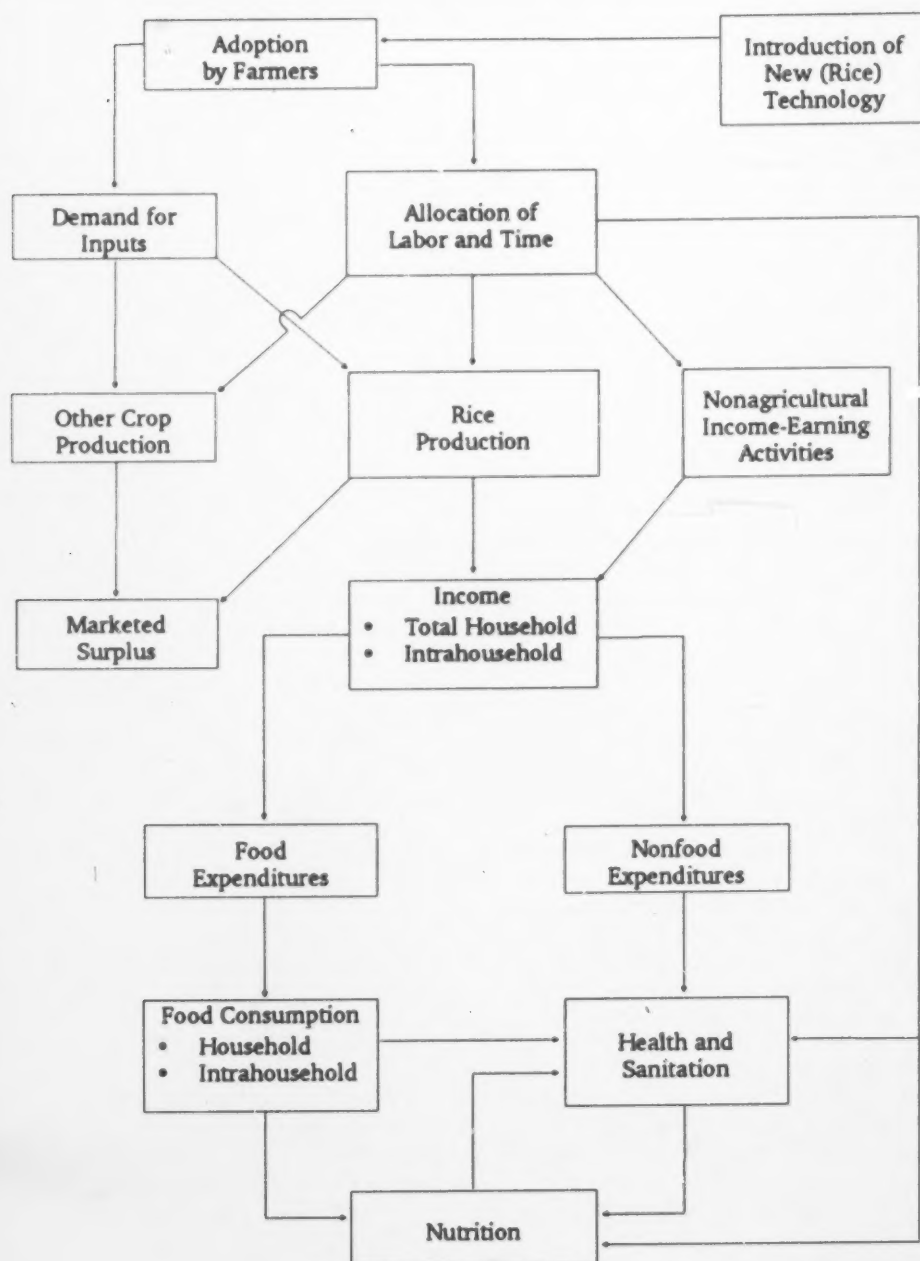
While the study takes an integrative view of household production, consumption, and marketing decisions, it refrains from building the analysis on an integrated household model,³ but rather conceptualizes the set of problems in terms of partial analyses within the framework of Figure 1. This route was chosen because the complexities of numerous structural relationships in the household production-consumption system would have been lost at the necessarily higher level of aggregation required for a closed household model. Also, the largely cross-sectional nature of the data suggests a cautious approach. There are inherent problems with unobserved latent variables and lack of independence among observations in a cross section. It is desirable to invest in building more longitudinal data sets in the long run to avoid these problems.

Figure 1 shows the conceptual framework followed in the analysis, at the same time providing an outline of the main themes covered by the report. The effects of technological change and commercialization on nutrition are mediated through (1) the nature of the new technology, (2) the adoption process and its production and income effects (and the resulting effects on employment and time allocation), (3) expenditure patterns and food consumption (which may not be uniform among the individuals of a household), and (4) the health environment that impinges on nutrition. The latter may be affected by expenditures on health and sanitation and by time-allocation effects of technology adoption "upstream" in the diagram (for example, mother's time allocation) or changes in the physical environment.

² A review of literature on the issue is provided in von Braun and Kennedy (1986).

³ On household models and their potentials for policy analysis, see Singh, Squire, and Strauss (1986).

Figure 1—Conceptual framework for analysis of household-level effects of new technology and commercialization



A better understanding of these critical relationships is essential to an identification of efficient modes of intervention designed to improve nutrition. The adoption of a given package of new technologies may involve certain trade-offs; for example, it may raise income but impose negative time constraints on child care. An early identification of such trade-offs and the design of corrective program components are essential to avoid short-term adverse effects of technological change on the poor.

The main methodological steps in the study, following the conceptual framework depicted in Figure 1, are the model analysis on access to new rice technology and adoption, the labor allocation model, the production function analysis, the marketed surplus analysis, the income earnings model, the food (energy) consumption model, and the models explaining nutritional status in the context of the health situation.

These models are designed so that the explained variables "upstream" in the diagram become explanatory variables "downstream" in the chain from technology to production to income to consumption to nutrition. But some feedback mechanisms should also be expected to work; for instance, better nutrition improving labor productivity. However, the intricacies of interactions in the household production system on the ground make the actual approach more complex than is depicted in the simplified diagram.

A brief sketch of the rationale and flow of analysis will be given here at the outset. Details follow in the respective chapters. The model sketches below are simplified and do not provide the specifics of variable definitions, precise units of observation, or time lags, but rather an overview on the flow of analysis and the conceptualization of exogenous and endogenous relationships in this analysis.

The introduction of new rice technology is treated as exogenous in this setting, but the degree of access to it by household units (compounds) is endogenous. The amount of land under new rice technology acquired by the household unit (HHACC) is hypothesized to be a function of location of village in project area (LOCATION), ethnicity (ETHNIC), demographics of household (HHDEMO), household status in local hierarchies (HHSTAT), and household wealth (WEALTH):

$$\text{HHACC} = f(\text{LOCATION}, \text{ETHNIC}, \text{HHDEMO}, \text{HHSTAT}, \text{WEALTH}). \quad (1)$$

This research, as well as the project around which it centers, is particularly concerned with the access of women—the traditional rice growers in the area—to the new rice technology. The probability of whether or not an individual woman within a household obtained access to land in the project (WOMACC; 1 or 0) is then hypothesized to be determined by the woman's demographic (WOMDEMO) and status characteristics (WOMSTAT) and by the degree of access of the household as a whole (HHACC, as dealt with in equation (1):

$$\text{WOMACC} = f(\text{WOMDEMO}, \text{WOMSTAT}, \text{HHACC}). \quad (2)$$

Introduction of new technology in one crop may substantially affect allocation of scarce resources to that crop and thereby reduce resource allocation to other crops. The focus is especially on the (re)allocation of labor (LABOR) by crop (j) as a consequence of access to new rice land (HHACC), because the new rice technology requires a lot of incremental labor input. Also included in this analysis of labor input is a set of variables depicting production conditions (PRODCON), labor force structures (LABSTRUC), and capital stocks (CAPITAL):

$$\text{LABOR}_j = f(\text{PRODCON}, \text{LABSTRUC}, \text{CAPITAL}, \text{HHACC}). \quad (3)$$

On the basis of crop-specific production functions (equation [4] below), whose main purpose is to estimate marginal labor productivities in this analysis, marginal output effects are derived from the estimated changes in labor allocation as a consequence of technological change in rice. The production functions for crops (j) consider labor input (LABOR $_j$), land and land characteristics (LAND $_j$, LANDCH), fertilizer use (FERT $_j$), technology use, such as appliances (TECHNO $_j$), and institutional arrangements under which the respective crop is grown, such as individual or communally grown crop (INSTIT $_j$), to depict the technical input-output relations in production (OUTPUT $_j$):

$$\text{OUTPUT}_j = f(\text{LABOR}_j, \text{LAND}_j, \text{LANDCH}, \text{FERT}_j, \text{TECHNO}_j, \text{INSTIT}_j). \quad (4)$$

Following the production analysis, the effects of change in output level and output composition are traced to their income and marketed surplus effects. The marketed surplus analysis focuses on the marketed outputs of cereals (OUTPUTMA $_j$), and attempts to explain these by the cereal production (CERPROD), prices (PRICE), income levels (INCOME), household demographics (HHDEMO), structure of crop composition along gender lines (WOMCER), and market-related infrastructure variables (INFRA):

$$\text{OUTPUTMA}_j = f(\text{CERPROD}, \text{INCOME}, \text{PRICE}, \text{HHDEMO}, \text{INFRA}). \quad (5)$$

In assessing the net income effects of technological change in agriculture at the household level, not only should the substitution effects in agricultural production be traced, but also those between farm and nonfarm income-earning activities. This is done in the context of an income-earning model in which income per capita (INCOME) is explained by upland crop-related agricultural capital (tools) and livestock capital (AGCAPITAL), human capital-related variables (HUCAPITAL), household demographics (HHDEMO), ethnicity (ETHNIC), and access to the new rice land (HHACC):

$$\text{INCOME} = f(\text{AGCAPITAL}, \text{HUCAPITAL}, \text{HHDEMO}, \text{ETHNIC}, \text{HHACC}). \quad (6)$$

The effects of changes in total budget availability (cash and in-kind) on spending patterns of households are then analyzed, and the effects on basic food consumption (calories) in the two main seasons of the year are modeled in greater detail. The conventional approaches of demand analysis are followed, enriched by structural variables that are determined by the local situation concerning food-consumption decision-making in the complex and large household units. Increased income is expected to raise food energy consumption per adult-equivalent person (CALORIE) but decreasingly so at the margin. The income effects are subject to the price situation (PRICE),⁴ given a certain composition of household (HHDEMO), nature of the income stream (cash share [CASHSH]), and income control in the household unit (women's share [WOMCON]):

$$\text{CALORIE} = f(\text{INCOME}, \text{PRICE}, \text{HHDEMO}, \text{CASHSH}, \text{WOMCON}). \quad (7)$$

Finally, the effects of food consumption (CALORIE) are traced to the nutritional status of children and women (NUTSTAT). Of course, numerous interweaving factors,

⁴ The role and potentially endogenous characteristics of consumer purchase prices in this model (equation [7]) and of producer sales prices (see equation [5]) due to seasonal variations are to be reviewed and are discussed in the respective sections of the report.

in addition to household-level food energy consumption (per adult equivalent), determine the nutritional status of children as quantified by anthropometric measures. Child-feeding practices, children's demographics (CHDEMO), household demographics that are important for the child-care environment (HHDEMO), the health record of child and mother (HEALTH), and the sanitation environment (SANIT) are most relevant. Also tested is whether increased access to new rice land with the new production technology had an additional effect on nutritional status besides those explanatory factors:

$$\text{NUTSTAT} = f(\text{CALORIE}, \text{CHDEMO}, \text{HHDEMO}, \text{HEALTH}, \text{SANIT}, \text{HHACC}). \quad (8)$$

The research was undertaken around the Jahally-Pacharr Smallholder Rice Project that is described in Chapter 4. The analysis is based on a series of sample surveys in 10 villages randomly selected from baseline information and 168 households (compounds) selected randomly in these villages. In some instances, these compounds are very large (up to 80 persons) and are subdivided into separate subunits of decisionmaking for production and consumption management. Taking this into account, there were 214 household units in the survey (for details on sampling, see the Appendix).

The main objective of the sample selection was to identify households that are, first, representative of the participants of the rice project and, second, involved in it to different degrees, thus providing the opportunity for a cross-sectional analysis of the project's effects on income and nutritional status. Since project land was distributed to villages according to traditional tilling rights in the swamps, a fairly large variation in plot size per capita is apparent for households between, and even within, different villages.

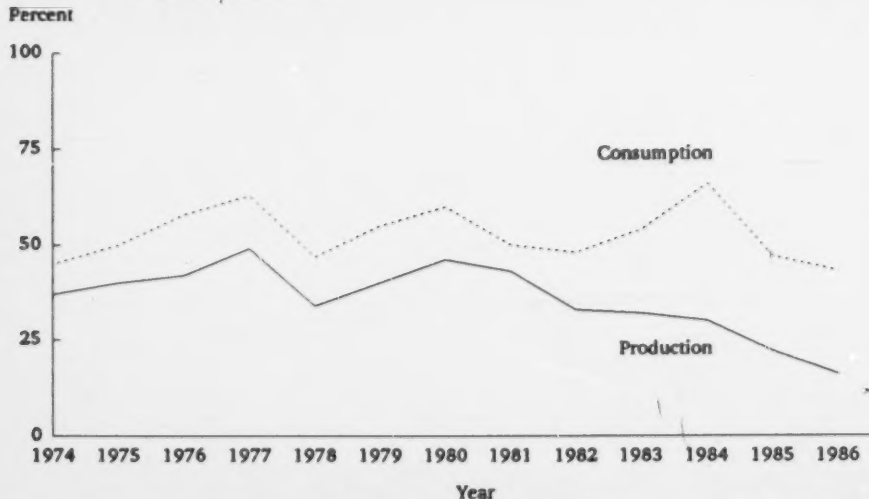
THE STUDY AREA AND ITS COMMERCIALIZATION THROUGH AGRICULTURAL PROGRAMS

The share of rice in total cereal consumption is traditionally high in The Gambia compared with neighboring West African countries. But domestic production in The Gambia has not kept pace with consumption growth, and the share of rice production in total cereals has declined, leaving a widening import gap (Figure 2). Better understanding of microlevel production relationships in the cereals sector and of rural consumption patterns and their determinants is required to design policies to cope with this import gap. This study contributes to the closing of related research gaps.⁵

Agriculture in the Study Area

The study area is located 300 kilometers east of Banjul on the south bank of the Gambia River (Figure 3). Population density is roughly 57 people per square kilometer. The area is inhabited by four different ethnic groups (Mandinka, Wolof, Fula, and Serahuli). Their villages range in size from 50 to more than 2,000 inhabitants, while their households have from 1 to over 80 people (the national average is 16). The

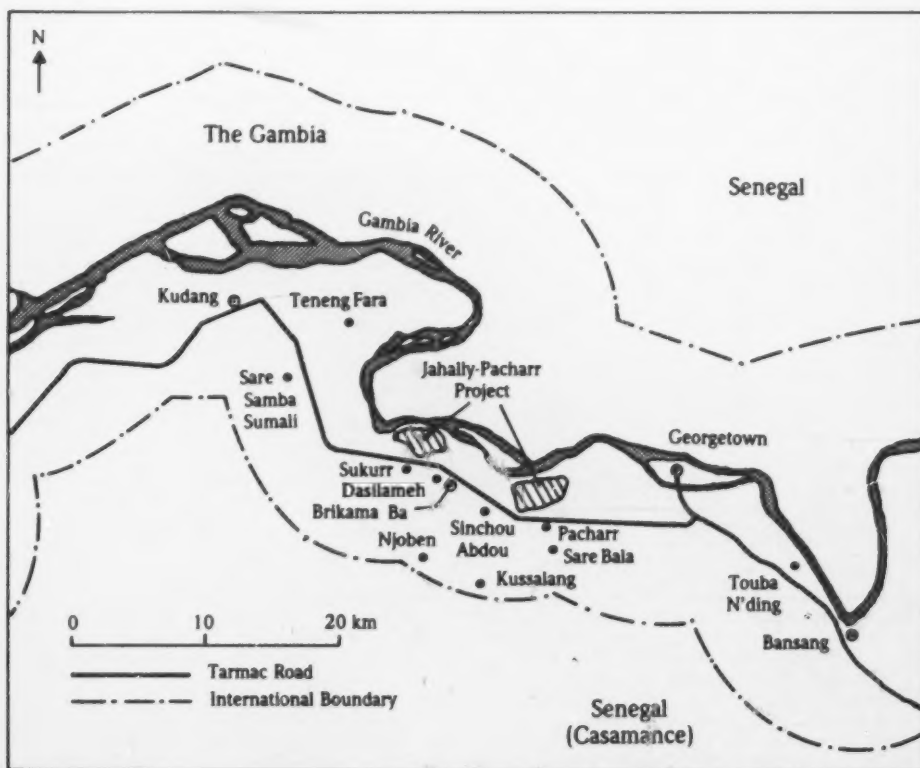
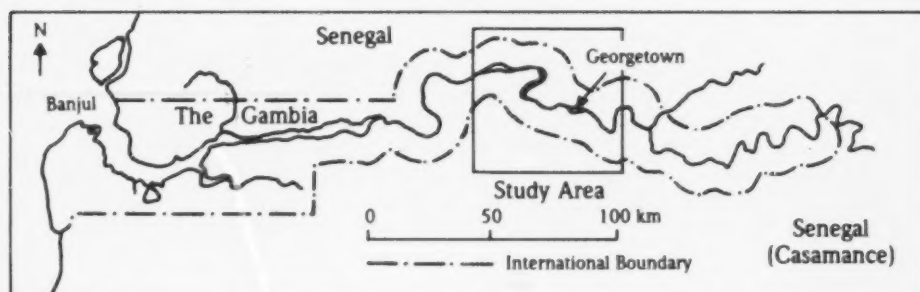
Figure 2—Share of rice in total cereal production and consumption in The Gambia, 1974-86



Source: Ken Johm, "National Production and Consumption Trends and Their Implications," in *Policy Issues for Rice Development in The Gambia*, ed. Sambou Kinteh and Joachim von Braun (Washington, D.C.: International Food Policy Research Institute, 1988).

⁵ A larger research effort on these issues is ongoing at IFPRI for the Sahel countries.

Figure 3—Map of the study area



Note: Survey villages are indicated with a black dot. Small towns in the area are shown with a circled dot.

population is almost entirely Muslim. Agriculture in this area is dominated by the seasonality of rainfall and the related cropping season from July to December. Groundnuts—the traditional and principal cash crop—cover almost 48 percent of the upland cultivated area in the sample villages (Table 1).⁶ The support system for groundnuts includes fertilizer credit, seed-improvement programs, and marketing arrangements. A number of other upland crops have also been promoted in the study area, but on a more minor scale. For example, a program promoting production of cotton (the secondary cash crop) was recently initiated with a subsidized input package. A small maize improvement scheme is also active in some of the villages in the study area. However, millet, the most important upland cereal, has largely been neglected.

This is in contrast to rice, which has been given the most support of all the staple foods, especially through irrigation schemes set up by the Taiwanese and the World Bank in the late 1960s and 1970s. Most of these schemes, however, have deteriorated, and they played only a minor role by the time the irrigation project that forms the focus of the present study was established in 1983/84. This project, the Jahally-Pacharr Smallholder Rice Project, has been the single most important factor in transforming agriculture in this area. A description of the project in the context of earlier rice projects is given in Chapter 4.

The commercialization process in the study area is not limited to groundnuts or to the influential rice project, but these, along with the smaller initiatives (cotton, maize),

Table 1—Shares of land area cultivated, by major crops, wet season 1985

Crop	Gambia Total	MacCarthy Island Division	Sample Villages ^a	
			Upland Villages	Lowland Villages
			(percent)	
Fully water-controlled rice in project ^b	0.3	1.0	2.7	10.0
Partly water-controlled rice in project ^c	0.3	1.0	1.9	7.0
Old irrigated rice schemes ^d	0.4	1.0	...	...
Swamp rice	10.0	13.0	1.0	18.0
Early millet	20.0	27.0	32.6	16.0
Late millet	9.0	1.0	0.7	2.0
Sorghum	5.0	5.0	3.9	5.0
Maize	8.0	9.0	7.0	10.0
Groundnuts	46.0	42.0	47.6	27.0
Cotton	1.0	1.0	2.6	5.0
Total	100.0	100.0 ^e	100.0	100.0

Sources: Data for the Gambia total and MacCarthy Island Division are from *The Gambia, 1986/1987 Agricultural Sample Survey Report* (Banjul: Planning, Programming, and Monitoring Unit, 1987); data for the sample villages are from the 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Upland villages in the sample are Njoben, Sinchou Abdou, Kussalang, Sukurr, and Sare Bala; the other villages are in the lowlands (see Appendix Table 57).

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^d These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^e Parts do not add to total because of rounding.

⁶ Besides being commonly known as a cash crop, groundnuts are an important food crop that provides a substantial share of the calorie and protein consumption requirements of the rural population.

drive the process. In addition, farming activities in livestock and vegetable production, as well as activities in the nonfarm income-earning arena (both inside and outside of the area, including resultant remittances) play a significant role in the overall market integration of the region under consideration.

Population and Infrastructure Characteristics

The population of the study area is relatively young. It was estimated that 43 percent were under 15 years old and barely 6 percent were over 60 years old.⁷ The overall sex ratio was 0.965 but this included large fluctuations within the age groups. Sixty-four percent of women aged 15-19 were married, compared with only 4 percent of men. A sample of women aged 40-59 reported having had an average of 7.2 live births of which, on average, four children were still alive.⁸

The majority of farmers involved in the study area belong to one of the four principal ethnic groups that inhabit the region: the Mandinka, Wolof, Fula (also known as Peul or Fulani), and Serahuli (also known as Sarakole). Although the study site is located entirely in The Gambia, the coverage of the various ethnic groups gives this study a substantial degree of representativeness for household systems in West Africa, since the four groups are widely spread and significant throughout this part of the region (Figure 4).

Long-standing cooperation and a marked absence of ethnically based rivalry or animosity have led to all four groups living peaceably side by side in neighboring villages or even within the same village. However, there are a number of distinctions between certain types of villages.

Upland and Lowland Villages

The first distinction to be drawn between villages is that of geographical location, which partially dictates the types of crops that can be grown at a given site. Gambian villages take the form of nuclear settlements. The land to which each village lays claim forms a band of varying width around the inhabited core. This band is not necessarily continuous or concentric, but is like a mosaic of fields scattered at various distances around the concentration of dwellings.

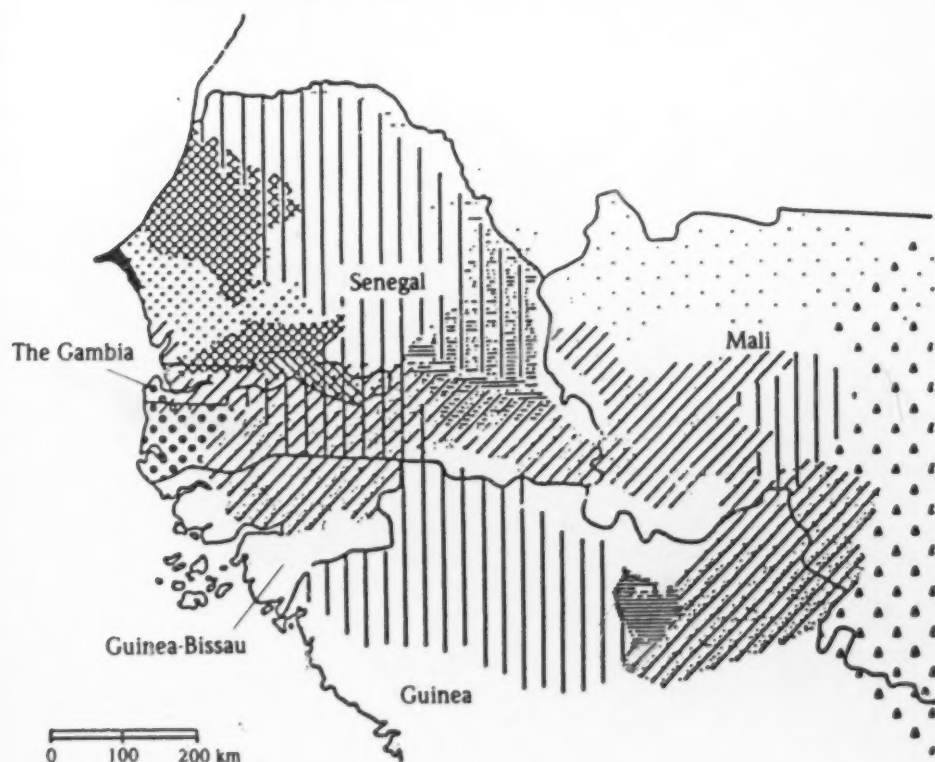
Depending on the village's location, this land is made up of either sandy detrital sediment of relatively low chemical fertility (upland soils) or more fertile hydromorphic soils located closer to the banks of the Gambia River and its tributaries (lowland soils) (Dunsmore et al. 1976). As a result of these soil characteristics, the agriculture of the upland villages traditionally leans toward upland cereal crops and livestock husbandry, while the lowland villages, although they have access to both types of land, traditionally place a much greater stress on rice.

While the distinction between upland and lowland villages should not be used too rigidly (because no place in The Gambia is more than 20 kilometers from the river), this is a useful division that will be referred to repeatedly in the analysis. Lowland villages can generally be equated with "traditional rice tillers" status (allotting an average of 18 percent of their total land area to swamp rice), while upland villages

⁷ Round 1 data for those present.

⁸ The sample consisted of all mothers or caretakers of children under 10 years of age.

Figure 4—Distribution of major ethnolinguistic groups in The Gambia and neighboring countries



Ethnic Groups

	Mandinka		Serahuli		Jola
	Wolof		Lebou		Toucoulor
	Fula		Serer		Bambara

Source: Kenneth Swindell, *Farm Labour* (Cambridge: Cambridge University Press, 1985).

have generally turned to rice production only in recent years and allocate only 1 percent of their land to swamp rice (see Table 1).⁹

Ethnicity, Size, and Growth

The second major distinction to be drawn between the 10 sample villages is their ethnic and historical background. As shown in Table 2, the sample includes a mixture of ethnicities in both the upland and lowland villages. The two villages not involved in the irrigation project are Mandinka. Not every village is ethnically homogeneous, however, and the ethnic label attached to each village refers to the predominant group of inhabitants.

Table 2 shows that two of the sample villages (one Fula and one Mandinka) are at least 100 years old. Another four are over 50 years old, but the remaining four have been founded since the late 1950s. Sinchou Abdou, the newest village, was settled in 1981 as a direct consequence of the Jahally-Pacharr project: the present village chief had suffered poor crops for several years as a result of drought and decided to move when he heard about the forthcoming irrigation scheme.

Sinchou Abdou was established by Gambians moving from one site within The Gambia to another. Yet not all of the sample villages have such origins: two were founded by migrants from Guinea Bissau, one is of Guinean origin, and two were settled by immigrants from Senegal. The 10 villages also show considerable diversity in size and in their recent rates of growth. During 1975-85, Pacharr expanded the

Table 2—Ethnic and historical characteristics of the sample villages

Village	Ethnicity ^a	Approximate Age of Village (years)	Founders' Country of Origin ^b	Number of Compounds in 1986	Population	Change in Number of Compounds 1975-85 (percent)
Upland villages						
Kussalang	Fula	100	Guinea	18	200	0
Njoben	Wolof	60	Senegal	50	1,200	+ 52
Sare Bala	Fula	17	Gambia	7	90	+ 17
Sukurr	Serahuli	27	Gambia	10	200	0
Lowland villages						
Dasilameh	Mandinka	80	Guinea Bissau	50	450	+ 56
Pacharr	Mandinka	100	Guinea Bissau	59	750	+ 136
Sinchou Abdou	Fula	5	Gambia	15	150	^c
Sare Samba						
Sumali	Fula	30	Gambia	16	130	+ 7
Nonproject villages^d						
Teneng Fara	Mandinka	80	Senegal	12	140	+ 50
Touba N'ding	Mandinka	60	Gambia	12	140	-20

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Few villages are ethnically homogeneous; this refers to the dominant group.

^b Country from which the village founders migrated to establish their present home.

^c Village founded in 1981.

^d Not involved in Jahally-Pacharr Smallholder Rice Project.

⁹ Table 1 shows that upland villages have a higher percentage of their total land in the form of project tidal-irrigated land than do the lowland villages. This is because the lowland villages (being traditional rice tillers) have priority for the best project land (pump-irrigated), leaving the lower-yielding tidal land to the upland farmers.

most rapidly (+ 136 percent), followed by Dasilameh (+ 56 percent), and Njoben (+ 52 percent). In other words, the three largest villages in the sample were also the fastest-growing villages during the decade preceding the study. Two of the upland villages (Kussalang and Sukurr) exhibit zero growth rate for this period, and only one village, Touba N'ding (outside the area of the rice project), shows a negative growth rate.

Services and Infrastructure

The next area of differentiation between villages relates to their access to infrastructure and services. Five of the sample villages are located less than 1 kilometer from the main tarmac road that runs the length of the country from Banjul to Bassé. These five villages are also only 5 kilometers or less from the project site. The remaining three villages involved in the project are located between 3 and 8 kilometers from the road, which places them 6-11 kilometers from the project rice fields (Figure 3).

Only one of the sample communities, Njoben, is served by a primary school in the village itself. Children in the other villages have to walk sometimes considerable distances each day to the nearest state-run school. Similarly, only one village, Pacharr, has a daily market within its confines. The other nine villages are located between 2 and 8 kilometers from such a market. Njoben, one of the villages farthest away from a daily market, compensates by having four small shops that sell durable commodities such as matches, kerosene, and batteries.

In addition to daily markets, a much larger market (attracting traders from as far as Banjul and Kaolack in Senegal) moves up and down the country each week. Villagers from Teneng Fara and Sare Samba Sumali visit it when it stops in Kudang. The inhabitants of Touba N'ding attend the market when it reaches Bansang. And all the other communities are within reach of the Brikama Ba stop.

In terms of health facilities, the only clinics providing rudimentary curative medicine are at Brikama Ba, Bansang, and Kudang (all on the tarmac road). Dasilameh's inhabitants are fortunate in living less than 1 kilometer from the Brikama Ba clinic. However, the other project-involved villages are also served by this one clinic, and their access to and use of its facilities are limited by distance (up to 20 kilometers in the case of Kussalang).

Every village has at least one "clean" well that is used as the principal source of drinking water for the community. Pacharr is unusual in having 17 such wells. A water analysis was carried out in all the sample villages in the dry season to discern whether there were major differences in quality that might affect the health of their inhabitants. The water analysis was conducted by quality control officers of the Ministry of Water Resources under contract with IFPRI. They took three samples from the main well in each village during the first week of September 1986, and carried out a coli count on site. The results indicate that Dasilameh, Sukurr, and Pacharr all enjoy relatively unpolluted water sources, while the other villages have access to less-clean water as measured by coli count. The significance of this factor for nutritional status of children is tested in the multiple regression analyses later in this paper and shows as significant.

Nonfarm Employment and "Strange Farmers"

A final set of distinctions may be drawn between the sample villages on the grounds of nonfarm activities and the functioning of local capital markets. Nonfarm income-earning activities, such as thatching, potting, and smithing, are found in all the villages. In some cases, there is only a handful of craft workers in a community. Kussalang, for instance, contains only three, and Sare Bala and Teneng Fara have only four each. Yet in the larger communities the number of craftspeople rises to a dozen or more. Sukurr is a special case; although only a small village, it has 24 craft workers among its farmers.

This is because two large households in Sukurr are traditional goldsmithing families and all the sons learn the art of smithing, while all the daughters learn the art of potting (a traditional association of the two skills by sex).

The same variation can be seen in the numbers of *marabouts* and "Strange Farmers" in each village. *Marabouts* are religious instructors who earn an income from teaching Koranic studies and from making magical charms. The new village of Sinchou Abdou has no *marabouts* yet among its inhabitants, in contrast with Dasilameh and Njoben, which have seven and eight, respectively. Strange Farmers are migrant workers who live in a village for one or more seasons, earning the right to grow a cash crop by exchanging their labor with a host for land and lodgings.¹⁰ Such agricultural migrants are attracted to the communities with the most "surplus" land, the best farm tools, and the best infrastructure. Pacharr and Njoben, for instance, had 50 and 61 Strange Farmers, respectively.

Functioning of the Economy at Village and Compound Levels

Interactions within the Village

Each village comprises an amalgamation of households, generally referred to as compounds, that are clustered around a central point usually occupied by a silk cotton tree, a well, and a shady meeting place.

There are strong village hierarchies defined by lineage status (a form of caste system whereby former slave-owning compounds rank at the top of a status pyramid, followed by village-founding compounds, free compounds, artisan compounds, and finally, ex-slave compounds) and by duration of residence in the village (Haswell 1953, Dey 1982). At this level, interpersonal relations are controlled by the village chief and council of elders.

Differences in approach to control of the village are manifest in a number of aspects of village organization. For example, to help poor or sick farmers, all 10 sample villages arrange communal work groups to which every compound is expected to send a representative. However, some villages gather for such communal work more often than others: Dasilameh reported 48 such engagements a year. Touba N'ding organizes such groups roughly 24 times a year. Njoben, although a substantially larger village than Touba N'ding, calls the communal work group together only 4 times a year.

Of course, compounds in Njoben, as in all other communities, can have their own individual cooperative arrangements to serve as bilateral support systems. Labor, tools, food, and many other resources are exchanged between family groups in the same village. While the large survey undertaken for this study captures the main transactions (for instance, labor and food), an in-depth study further explores these linkages (Webb 1989). Such links may also include the exchange of youths for marriage and often date back several generations. It is unusual for any given compound to enjoy close links with fewer than three other compounds in their community.

The Compound Economy

The Gambian compound is the structure that serves as the arena for family interactions. In physical terms, the compound constitutes a collection of dwellings, kitchens, and storage huts clustered around a central courtyard and fenced off from the pathways outside. The average number of people living in the compounds studied was 13.7 but

¹⁰ For more details of the Strange Farmer system, see Swindell (1985) and Robertson (1987).

the range was from 2 to 86. Compound size was related to ethnicity (Serahuli had the largest mean, 19.4 persons, and Fula the smallest, 11.4 persons). Size was also related to age. New compounds tended to be smaller; those less than 1 year old averaged 8.3 persons, while those over 10 years old averaged 15.8.

The nucleus of the compound membership is a grouping of blood-related kin, but the total household may also include more distant relatives and even unrelated Strange Farmers among its inhabitants. Each household member holds a well-defined position in the compound micro-society that is ascribed according to hierarchies of age, sex, and marital status.¹¹ Ultimate responsibility for the maintenance of productive cooperation lies with the compound head. Yet the compound head is not omniscient. However powerful and domineering a single figure of authority may be, it is impractical for one person to make all the decisions that are necessary in the running of a large household of diverse individuals. Subdivisions of distinct spheres of responsibility and activity are apparent in many (especially larger) compounds.

The Compound Subunits

There are two main kinds of subdivision of the compound unit. On the one hand, compound membership may be subdivided into *dabada* and *sinkiro*. On the other hand, the compound farm is divided into a communal *maruo* section and private *kamangyango* sections.¹²

The *dabada* (a Mandinka word deriving from the noun *daba*, or hoe) is generally defined as a farm production unit. If all members pool labor to produce food on which the compound subsists, then the *dabada* is coincident with the compound. This is the case in 86 percent of the sample compounds. If, however, two or more groups of individuals living within the same compound decide to split their farming ventures, then that compound may contain as many as four *dabadas* (the sample contains 16 compounds with two *dabadas* and four compounds with four *dabadas* each). *Dabada* structures change frequently. Therefore, production data were gathered on an individual field-by-field basis from each person responsible for fields in each whole sample compound.

Cooking and consumption groups, called *sinkiros* in Mandinka, provide the basis for the compound's organization of storage, processing, and consumption of food. In larger *sinkiros* several women may be responsible for cooking; typically, each woman cooks on a rotational basis. The head cook of the *sinkiro*, usually the highest-status active female, supervises the cooking procedures, establishes the duty roster of the cooks, and organizes the provision of ingredients.

The cooked food is normally divided into a number of bowls that are presented to "eating groups." Many combinations of these eating groups are possible in a compound by age and gender. Sometimes people from different *sinkiros* join in eating groups, but rarely people from different compounds.

Among the Mandinkas, the women of the same *sinkiro* traditionally also work together as a distinct production unit. A *sinkiro* is thus not just a cooking unit in these instances where the women produce traditional rice as both a communal and an individual crop independently from the male-headed *dabadas*.

In most of the sample households, the *dabada* and *sinkiro* units coincide with the compound (80 percent of the compounds have only one *dabada* and one *sinkiro*). Some

¹¹ For a more detailed account of the decisionmaking structures of intracompound hierarchies, see Webb (1989).

¹² For complementary accounts of Gambian household organization, see Dey (1982) and Dunsmore et al. (1976).

of the larger compounds may be subdivided into several working and consumption groups. Ethnicity plays a role in this pattern. In the study area, this applies especially to Mandinka and Wolof compounds, where some of the traditional responsibilities of the compound head are transferred to the heads of the subunits.

In subdivided compounds, where the number of *sinkiros* equals the number of *dabadas*, all persons of one *sinkiro* usually also belong to the same *dabada* and the other way around. But sometimes *dabada* and *sinkiro* may differ: people from different consumption groups may pool their labor in one working group and share the produce after harvest. Such situations apply to 15 of the sample compounds. In these cases, the *sinkiro* was identified as the most stable and important decisionmaking unit for production, storage, and consumption decisions, even when agricultural production was technically organized partly in a different working unit. The final decision about the appropriate unit of observation was taken only after careful evaluation of each of the more complex cases of nonidentical production and consumption units within compounds.

The compound farm is also divided into two distinct parts: the communal *maruo* farm and the private *kamangyango* farm (communal refers to compound or *dabada* level, not to village level).

The *maruo* farm comprises a set of fields that is designated to provide the bulk of the food that will be required by the household until the following harvest. This enterprise, fundamental to the maintenance and survival of the compound group, is under the control of the compound head, either directly or through a production manager.

The harvest of a *kamangyango* field, by contrast, is allocated for individual rather than communal disposal. Any person in the compound (including the compound head) has the right to a *kamangyango* field for which he or she will be solely (or sometimes jointly) responsible. The number of *kamangyango* fields is naturally limited to the stock of land available to the compound and to the extent to which the head is prepared to subdivide existing fields. Boys and girls frequently get their own *kamangyango* field before the age of 14.

The communal crops are produced by the combined labor of all compound members—all men and women have a customary obligation to provide labor to the communal fields. Labor for the private crops, on the other hand, is organized by the individual who is responsible for the field. Individuals can choose to provide as much or as little labor to this crop as they want. However, this becomes one of the focal points of competition between personal interest and cooperation with the rest of the compound group. For those men and women with access to private fields, time spent on the communal farm or on other people's farms is time spent away from private crop production. And time spent on the private farm is time away from communal food production and time away from helping others.

This problem of balance between cooperation (adding to total availabilities) and conflict (dividing total availabilities among the members of the household) constitutes one of the so-called "bargaining problems" discussed by Sen (1985). The most common way that compound heads attempt to resolve the problem is to assign two or three days in the week as *maruo* workdays, on which all able-bodied compound members are expected to provide labor to the communal fields under the direction of the head, and the rest of the week as *kamangyango* workdays, during which individuals may allocate their own labor as they please. This allocation of up to three or four days a week to private farming results in a considerable amount of intrahousehold labor sharing at the individual level. Rather than pursue an individualistic concentration of labor

inputs on their own plots, most farmers appear to favor a high level of cooperation among household members.¹³

Intrahousehold cooperation in the spheres of labor exchange and resource control was found to be an important factor in the successful adoption of the technology package offered by the Jahally-Pacharr rice project.

¹³ This aspect is covered in von Braun and Webb (1989).

PRODUCTION EFFECTS OF COMMERCIALIZATION AND TECHNOLOGICAL CHANGE IN RICE

The country's first step toward expanding and improving rice production was taken in 1948 by the British Colonial Development Corporation. This initiative was driven by a desire to reduce costly food imports, which had become a necessity to offset frequent shortfalls in food production in various parts of the country caused by drought and insect damage. The swamps around Pacharr in the present study area were selected as the site for a planned 9,200-hectare irrigation scheme. Irrigation was achieved through the canalization of leveled fields, fed by the tidal flow of the river. The scheme was run on a plantation basis, with heavy work carried out by tractor; local labor was required only as daily paid hands for weeding. The first 60 hectares were planted in 1950, but only 6 hectares survived flooding that year because of insufficient drainage. Also, the heavy machinery was difficult to operate in the slippery conditions. Therefore, it was decided to involve local farmers on a sharecropping basis, but the scheme was not attractive enough to encourage the participation of many farmers. By 1958, fewer than 200 women had joined, cultivating a mere 120 hectares, and the scheme was abandoned in that year.

With support from Taiwan, the development of rice irrigation was resumed in 1966 around the area of Georgetown (30 kilometers upstream from the present survey area). This scheme was designed to assist farmers in establishing their own small perimeters for pump-irrigated double cropping. Inputs, such as fertilizer, seed, and fuel, were provided free for the first year, but farmers were expected to meet all costs themselves in subsequent years. The attraction of free inputs resulted in the development of 1,200 hectares by 1974. Since no support was given to farmers after the first crop, yields and productivity levels declined rapidly. Flooding continued to be a problem because of deficiencies in technical design. Unlined canals leaked and the lifespan of pumps and tractors was short because they were ill-adapted to local conditions.

The Taiwanese mission finally withdrew in 1974 to be replaced by personnel from mainland China. The latter committed themselves to furthering the work that had previously been carried out, using the same methods. However, by 1980, only 500-800 more hectares had been developed, and this scheme was suffering the same problems as its predecessors: mechanical failures, flooding, and declining yields.

Between 1972 and 1977, the World Bank also sponsored a scheme to consolidate the existing Taiwanese irrigation perimeters and to develop a further 1,200 hectares. The main departures of this scheme from the Taiwanese model were the continuous provision of inputs on credit and the establishment of a strict timetable for cultivation activity that farmers were expected to adhere to or be expelled from the scheme. When it was completed in 1977, less than two-thirds of the target area was developed, and countless farmers were falling behind on their loan repayments. By 1982, only 30 percent of the perimeters undertook dry-season irrigation and less than 10 percent attempted a wet-season crop. Nevertheless, some of the World Bank and Taiwanese perimeters continue to survive and to produce mainly wet-season crops. It is these perimeters that are referred to in later text and tables as the "old schemes."

Despite these many setbacks, The Gambia's planners have remained committed to the idea of large-scale irrigation. The latest attempt is the Jahally-Pacharr Smallholder

Rice Project, which is also seen as a pilot scheme to assess potentials for large-scale irrigation that could technically be developed following construction of a barrage that would prevent saltwater intrusion and permit regulation of river water flow in the dry season. Under the leadership of the International Fund for Agricultural Development (IFAD), the project is funded mainly by foreign donors and managed jointly by the Gambian Ministry of Agriculture and outside consultants.

Cost of Rice Production under Various Technologies

It is widely recognized that costs of irrigation schemes in Sub-Saharan Africa are high by Asian and Latin American standards. West African cost figures rank high even within the unfavorable African experience. However, comprehensive comparisons based on analogous calculations are lacking. Rough estimates suggest that new schemes in Africa cost 64 percent more than in the Far East and 55 percent more than in Latin America (FAO 1986, 39-49). This appears to be due to higher input (transportation), staff, and management costs. As the Food and Agriculture Organization of the United Nations (FAO) has underlined, "When all items of a project are added together, they tend to confirm the general statement that irrigation in Africa 'now costs US\$15,000-20,000 per hectare,' provided that the definition of 'irrigation' includes full water control with pump supply on a site requiring a complete range of technical and production support services as well as social infrastructure" (FAO 1986, 42).

The Jahally-Pacharr project is no exception to that general statement. Conservative estimates suggest an investment cost of US\$9,322 and total establishment costs of US\$14,481 per hectare of irrigated land (all types) (Table 3). Investment costs cover

Table 3—Planned investments and running costs during establishment of the Jahally-Pacharr project, 1983-87

Investments/Costs	Share of Total Cost ^a	Cost per Hectare of Irrigated Land at Full Development, 1987 ^b
	(percent)	(US\$) ^c
Investments		
Civil works		
Land development	40.6	
Other	11.2	
Equipment, machinery, vehicles	12.6	
Subtotal	64.4	9,322
Running costs for project establishment		
Fuel	0.5	
Spare parts, maintenance	0.5	
Personnel (including expatriate staff)	22.6	
Subtotal	35.6	5,159
Total	100.0	14,481

Sources: Computed and estimated from Jahally-Pacharr project reports.

^a Expenses for monitoring and evaluation and for social services are excluded.

^b The land is expressed on a "pump-irrigated land equivalent" basis. The land area at full development of the project used for this calculation consists of 560 hectares of pump-irrigated land, 500 hectares of tidal-irrigated land, and 450 hectares of rainfed land. The respective areas are weighted on a yield basis. This results in 991 hectares of "irrigated-land equivalent."

^c U.S. dollars are converted from special drawing rights (SDR) (1 SDR = US\$1.216).

about 64 percent of establishment costs and most of this is for land leveling. While the experience of yields in irrigation projects is not very encouraging in many West African situations, this project stands out with impressive yields of about 5-6 metric tons¹⁴ of paddy per hectare twice a year (from the pump-irrigated and drained and fully water-controlled plots). Project operating costs recently stood at US\$317 per ton (excluding farmers' inputs and labor). As production costs for rice differ substantially by type of production technology, economic cost estimates are presented by technology later after a brief description of the project.

The Jahally-Pacharr project was initiated in 1983. By 1986 it covered 560 hectares of centrally pump-irrigated land, 188 hectares of tidal-irrigated land, and 432 hectares of improved rainfed land. Two crops a year are harvested from the centrally pump-irrigated plots. Only one annual crop is usually harvested from the partly water-controlled land, which is partly tidal-irrigated and partly improved rainfed rice or a mix of the two.

Land in the project is distributed to about 7,500 farmers who cultivate an average of 0.43 hectare of fully water-controlled equivalent land per compound.¹⁵ Farmers repay loans for land preparation, water, seed, and fertilizer charges by selling back part of their produce to the project immediately after harvest.¹⁶ Loan repayments showed an unusually good record in the first few years of project operation, with 92-99 percent recovery, but have declined in recent years, when yields have been lower. The charges to the farmer on a per hectare basis represent 25 percent of the average output per hectare in 1986 and have been adjusted to increased input cost over the years.

Producer prices for project paddy paid by the local cooperative were D945 in 1986.¹⁷ This is equivalent to US\$263 per ton of white rice at a parallel exchange rate (in 1986, US\$1 = D6) and a milling rate of 0.6. The white rice price for consumers in Banjul in 1986 was about D1,793 (US\$299). Rice was taxed both through import restrictions and through a direct tax, which amounted to a 44 percent tax rate for urban consumers in 1986. Between 1977 and 1985, this ranged between a tax of 25 percent and a subsidy of 10 percent, with the average being a 15 percent tax.¹⁸ Thus, during the 1980s, The Gambia was not among those countries that pursued a "cheap food policy" by world market standards.

In the following cost calculations, a distinction is made between fully water-controlled (pump-irrigated) rice in the project that yields two crops a year, partly water-controlled rice in the project that yields one crop a year (tidal-irrigated and rainfed), and swamp rice outside the project. Cost calculations per hectare and per ton of milled rice are broken down by major cost categories and by domestic and foreign exchange costs in Table 4. The analysis is then further developed to include domestic resource cost (DRC) calculations in Table 5.¹⁹

The DRC approach is used to estimate comparative advantage in rice production under alternative technologies vis-à-vis the import option. The DRC is thus the cost in

¹⁴ All tons referred to in this report are metric tons.

¹⁵ For comparative purposes, land in the project is expressed in "fully water-controlled equivalent land" based on the different yield levels.

¹⁶ Cash payments are also possible, but this option has only recently been chosen to a more significant extent by farmers.

¹⁷ D is the currency abbreviation for the Gambian dalasi. In September 1985, US\$1.00 equaled D3.50 at the official exchange rate and D5.06 at the parallel market rate; in June 1987, US\$1.00 equaled D7.50, with little difference between the official and the parallel rates.

¹⁸ For the detailed price and tax calculations based on the parallel exchange rate and taking account of handling costs, see Johm (1988).

¹⁹ On the concept of DRC, see, for instance, Bruno (1972) and Gittinger (1982).

Table 4—Production costs of rice in various technologies, 1985

Position	Share of Foreign Cost (percent)	Production Costs of Jahally-Pacharr Project Rice						Production Costs of Swamp Rice (Single Crop)		
		Fully Water-Controlled Rice (Sum of Double Crop)			Partly Water-Controlled Rice (Single Crop)					
		Total	Domestic	Foreign ^a	Total	Domestic	Foreign	Total	Domestic	Foreign
		(dalasi/hectare)		(US\$/hectare)	(dalasi/hectare)		(US\$/hectare)	(dalasi/hectare)		(US\$/hectare)
Investment costs ^b										
Operation cost (annual)	75	5,370	1,342	796	1,497	373	222	...	...	...
Other variable production cost ^c	90	1,785	179	317	432	43	77	...	...	...
Opportunity cost of unpaid labor ^d	46.25	1,860	1,004	169	527	265	48	160	120	8
Milling and handling ^e	15	1,427	1,213	43	756	643	22	718	610	21
Total cost per hectare	50	937	468	93	286	143	28	121	61	12
Share of equivalent foreign exchange cost in total cost (percent)		11,379	4,206	1,418	3,498	1,487	397	909	791	41
Share of investment cost in total cost (percent)		(63.1)			(57.5)			(20.8)		
Total costs per metric ton (dalasi) ^f		(47.1)			(42.8)			(0.0)		
Total costs per metric ton, excluding investment cost (US\$)		1,635	604	204	2,082	885	236	1,297	1,027	53
		323			411			256		
		171			235			256		

Source: Computed and estimated from Jahally-Pacharr project reports.

^a Computed at shadow exchange rate when conversion required (1985: US\$1.00 = 5.06 dalasi).

^b Total investment costs annualized based on 10 percent interest and 30-year repayment period. Fully water-controlled land required investment cost of US\$10,000 per hectare; partly water-controlled, US\$2,792 per hectare.

^c Economic cost for situation with the average sample survey yields (fertilizer, seeds, and so forth); 46 percent refers to "fully water controlled." Using prevailing male and female wage rates in respective seasons (wet season, D3.50; dry season, D1.50). Fifteen percent of the opportunity cost of unpaid labor is specified under foreign cost. This 15 percent is estimated to represent the average share of unpaid labor's opportunity costs accounted for by foreign exchange-earning activities (seasonal groundnut production in neighboring Senegal and other migration-remittance relationships).

^d Based on 10 percent of value of output.

^e Based on mean rice yield (milled rice, metric tons per hectare per year) from sample survey: fully water-controlled rice, 6.96 tons; partly water-controlled rice, 1.68 tons; and swamp rice, 0.77 tons.

Table 5—Domestic resource cost calculations for various rice technologies, 1985/86

Position	Jahally-Pacharr Project Rice		Swamp Rice
	Fully Water-Controlled	Partly Water-Controlled	
	(cost/metric ton of milled rice)		
Domestic production cost (dalasi) ^a	604	885	1,027
Rural marketing (dalasi)	71	71	71
Total domestic production cost (dalasi)	675	956	1,098
Foreign production cost (US\$) ^a	204	236	53
Domestic cost of importing rice into rural market (dalasi)	125	125	125
Foreign cost of importing rice into rural market (US\$) ^b			
100 percent broken (Thai)	195	195	195
5 percent broken (Thai)	288	288	288
Domestic resource cost (DRC) ^c			
100 percent	negative	negative	6.85
5 percent broken	6.55	15.98	4.14
Resource cost ratio			
100 percent broken	negative	negative	1.35
5 percent broken	1.29	3.16	0.82
Critical c.i.f. import price of rice at which DRC would equal shadow exchange rate (US\$1.00 = D5.06)	313	400	245

Source: Calculated from Jahally-Pacharr project records and the 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: The calculations are based on the finding that the rural area of The Gambia is a net importer of rice. This is the case even if appropriate adjustments for border trade are made and is also confirmed by household-level supply and disappearance balances based on the International Food Policy Research Institute/Planning, Programming, and Monitoring Unit survey.

^a For details, see Table 4.

^b C.i.f. price Banjul (US\$187/metric ton of 100 percent broken Thai rice and US\$280/ton of 5 percent broken) plus foreign marketing cost into rural markets of US\$8/ton.

^c The domestic resource cost (DRC) is computed as follows on a per-ton-of-rice basis: $DRC = (Total\ domestic\ production\ cost - domestic\ cost\ of\ importing\ rice\ into\ rural\ market) / (Foreign\ cost\ of\ importing\ rice\ into\ rural\ market - foreign\ production\ cost)$. For example, with the figures for fully water-controlled rice and the 5 percent broken-rice quality: $DRC = 6.55 = (675 - 125) / (288 - 204)$.

domestic currency required to earn one unit of foreign exchange through a project. In economic analysis, a project is deemed successful if the DRC is less than the shadow exchange rate (Gittinger 1982, 398-400, 468). In the case under consideration, the DRC is the ratio of domestic cost of production and the difference between the border price of rice and the foreign exchange content of production and marketing costs:²⁰

$$DRC = \frac{\text{Domestic cost of production in shadow prices per ton}}{(\text{c.i.f. import price per ton} - \text{foreign costs per ton})} \quad (9)$$

Comparative advantage may be measured by the resource cost ratio (RCR) of DRC and the shadow exchange rate (SER) of the currency:

²⁰ As rural Gambia is a net importer of rice, the cost calculations are for a rural market point in the study region in central Gambia.

$$RCR = DRC/SER,$$

(10)

and if

$RCR > 0$ and < 1 , advantage; 1, neutral; and > 1 , disadvantage.

The calculations are made with 1985 prices, assuming sustained yield levels.

The cost of rice production per unit (ton) is higher in the two more advanced irrigation technologies than in swamp rice but decreases for the advanced technologies if investment cost is excluded. The share of foreign cost in total cost increases from 21 to 63 percent when swamp rice is compared with fully water-controlled rice.

The share of investment cost in total cost of the new technologies is 47 percent for fully water-controlled rice and 43 percent for partly water-controlled rice. The high cost of production per unit and the fact that the DRC exceeds the shadow exchange rate result from the high investment costs, which are mainly (75 percent) met from foreign capital.

While almost all of The Gambia's rice imports are 100 percent broken rice (which was available for an average of US\$187 per ton in 1985), the critical import price at which domestic production at current cost structures and exchange rate would be viable is US\$313 per ton in fully water-controlled rice and US\$400 per ton in partly water-controlled rice. Swamp rice production is closer to competitiveness with a critical import price of US\$245 per ton. If the import price of rice were at US\$280 (which was also the 5 percent broken rice price in 1985), the fully water-controlled rice would show a DRC of D6.55—that is, to earn/save US\$1.00, D6.55 is being expended in this technology, which is slightly above the shadow exchange rate of D5.06/US\$1.00 in 1985.

These cost calculations give broad insights into the trade-offs between technologies. Clearly, cost of production has to come down substantially if the partly water-controlled rice technology is to be competitive. Yield potentials also need to be more fully exploited.

Because of a water shortage in the dry season, there is only a limited possibility for further expansion of fully water-controlled rice in The Gambia. Consequently, although almost viable under assumed long-term trends of international rice prices and under optimal project management conditions, this technology cannot hold the key to expanded rice production in The Gambia in the future. The future may be somewhere between the tested partly water-controlled technology (tidal and improved rainfed irrigation) and traditional swamp rice. However, it appears that partly water-controlled rice is not viable as analyzed here, because of large land-leveling and related investment costs. Smaller perimeters that require a lower per hectare leveling cost and still achieve comparable yields appear more competitive. In this context, it should be stressed that the partly water-controlled rice in the project shows a particularly broad spectrum of yield achievements (discussed later in this chapter). The project's function of identifying successful technologies within this setting has therefore been an important one in order to avoid misallocation of resources in future project designs.

The remaining part of this chapter describes and analyzes production relationships at the microlevel and how they are influenced by the new rice project. The analysis comprises, first, an analysis of the adoption of new technology, which in this case means gaining access to land in the project. Second, a quantitative account is given of how the division of land and labor between sexes, and between communal and individual farming, is changed by the new technology. Third, the effects on the output and labor productivity of various groups of farmers and on the crops that they produce are evaluated.

Access to the New Technology

Responsibility for crop production is divided between men and women. Men organize the bulk of upland cereals production, being responsible for more than 90 percent of those fields; women, on the other hand, organize swamp rice production (Gamble 1949, Weil 1973)—more than 90 percent of swamp rice fields are under female control. Both men and women are in charge of organizing traditional cash crop production. Women control close to 40 percent of all groundnut and cotton fields (Table 6), producing 28 and 29 percent of output, respectively.

Access to the new production technology—pump and tidal irrigation, coupled with fertilizer and improved seed—is tied to participation in the project. As project production is closely supervised, the "adoption" of new technology is largely synonymous with getting access to new rice land in the project through a more or less rationed distribution of land to villages, then intravillage to compounds, and finally within compounds to individuals or groups of compound members.

This distribution of the new rice land to farmers in the project poses problems of equity and efficiency. It is an issue of differentiation between villages, between compounds of the same village, and between male and female farmers of various socioeconomic characteristics in the same compound. In the Jahally-Pacharr project an equity-oriented approach to land distribution was attempted, whereby 0.5-hectare plots of land were given out to be shared, usually by compounds of the same village. As many as five compounds or different *sinkiro* groups may share the same 0.5-hectare

Table 6—Control over fields, by sex and male status in the compound, wet season 1985

Crop	Number of Fields in Sample	Fields Under Men's Responsibility		Fields Under Women's Re- sponsibility
		Total	Under Compound Heads	
(percent of all fields)				
Fully water-controlled rice in project ^a	174	90	69	10
Partly water-controlled rice in project ^b	103	23	22	77
Pump-irrigated rice in old schemes ^c	28	32	21	68
Swamp rice	302	9	2	91
Total	607	36	26	64
Early millet	302	91	53	7
Late millet	17	94	59	6
Sorghum	65	98	72	2
Maize	214	98	70	2
Total	598	95	62	5
Groundnuts	636	61	22	39
Cotton	83	63	22	37
Total	719	61	22	39
All crops	1,924	63	35	37
All crops, excluding rice projects	1,619	64	33	36

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

plot and subdivide it. Land was distributed across a wide range of villages, some of which were inhabited by traditional rice farmers located close to the project, and others, farther away from the site, whose farmers had not been involved in rice farming before.

Land distribution criteria laid down at the outset stressed that priority access to project land would be accorded to traditional rice-cultivating villages (lowland villages that were much involved in swamp rice production before the project) and especially to women (Altarelli-Herzog 1983, 1984). Land allocation committees were set up to distribute quotas of plots to villages wishing to participate. At the village level, distribution committees were to organize the final distribution to compounds and individuals. In the event, different procedures were adopted by the project and consequently different patterns of distribution emerged. The final distribution at village level was handled very differently from village to village, depending on committee organization, the position of women in respective ethnic groups, and so forth. Thus the outcome of the distribution process poses important research questions that are more fundamental than simply whether administrative procedures were actually adhered to or not.

On average, 0.43 hectare was allocated per household unit (compound).²¹ Equality of distribution varies considerably between villages (Appendix, Table 57) and within villages.

A more refined approach is used to assess the main determinants that shaped the final outcome of the land distribution. First, the characteristics of compounds that succeeded in obtaining more versus less of the project rice land are analyzed. Second, the factors that determined the probability of individual women gaining access to project land, and thus to the new production technology, are analyzed (see models shown in equations [1] and [2] in Chapter 2).

The first approach uses a regression model in which the amount of land per compound is the dependent variable. It was hypothesized that the size of a compound, its location in an upland or lowland village, and long-term residency and ethnicity affected the distributional outcome. Also, a test was conducted if compounds that had more land and farm capital endowments before the project had more access than others. Results of the multivariate analysis on compound-level distribution are presented in Table 7. The results suggest that the pattern of access does not fit a simple rich/poor or small farm/large farm distribution. All else remaining the same,

- Upland village compounds obtained 0.30 hectare less than those in lowland villages (variable 3), holding compound size constant (variables 1 and 2).

- Larger compounds (with larger work forces) obtained more land but at a decreasing rate (variables 1 and 2). Thus smaller units fared better on a per capita basis.²²

- Mandinka compounds, traditionally more involved in rice production (by women), obtained significantly more access than all other ethnic groups (Wolof and Fula access is not significantly different from that of Serahuli) (variables 8, 9, and 10).

- Compounds that settled in the village longer than 10 years ago received on average 0.09 hectare more than their younger counterparts (variable 4). Higher status, which is usually related to compound age, affected project access significantly.

- Farm size and capital stock before the project did not significantly affect project access. There is thus no indication that the better-endowed compounds got significantly more access to the new technology (variables 5, 6, and 7).

²¹ This area is expressed in terms of "fully water-controlled land equivalents," meaning that all rainfed and tidal-irrigated fields are converted on a yield-per-hectare basis to fully water-controlled land.

²² For aggregate comparisons, persons are aggregated to adult-equivalent units on the basis of FAO-recommended calorie requirements: men = 1.00, women = 0.85, male 10-14 = 0.95, female 10-14 = 0.83, children 5-9 = 0.81, children 0-4 = 0.52.

Table 7—Determinants of access to land in the rice project, by compound (multivariate analysis)

Explanatory Variable	Parameter	t-Value
(1) Size of compound in adult-equivalent persons	0.0314	5.72
(2) Size of compound in adult-equivalent persons squared	-1.6024E-4	-1.73
(3) Upland villages (= 1, else = 0)	-0.2963	-4.32
(4) Long-term resident (compound older than 10 years)	0.0904	2.21
(5) Before-project farm size per adult-equivalent person	-0.0291	-0.17
(6) Before-project farm size per adult-equivalent person squared	0.0514	0.50
(7) Before-project farm capital per adult-equivalent person	6.4942E-4	0.64
(8) Mandinka	0.2661	2.86
(9) Wolof	-0.0658	-0.56
(10) Fula	0.0543	0.53
Constant	0.0144	
R ²	0.718	
F-value	38.77	
Degrees of freedom	138	

Note: Dependent variable—amount of rice land in the project per compound in hectares (in fully water-controlled land equivalent).

The project's land-distribution policy was specifically aimed at ensuring women's access to the project rice land. Women were given land titles (long-term leases) in a formal registration process. To what extent this process translated into women's de facto control over land, and the right to cultivate it as their own *kamangyango* (personal) fields, was assessed separately. Results are taken from a random sample of women who reported having worked in the project fields in 1985/86. The results show that 52 percent of the women reported that they are *registered* as being responsible for a piece of project land. However, only half of those women actually control a field or are able to share one with other women. On the other hand, 29 percent of *unregistered* women have access to fields, mainly by sharing. Thus a total of 40 percent of the women in the sample ended up with a piece of land under their control. Nearly all of these fields are of the lower-yielding tidal-irrigated or rainfed type; only 10 percent of fully water-controlled fields are under female control, compared with 77 percent of the tidal/rainfed fields (Table 6). Most of the surveyed women (87 percent)—whether registered or not—work in the communal project fields.

The question of what determined women's access, or nonaccess, to the new rice fields is addressed next. A probit model is used to assess the factors that enhanced or reduced the probability of women's access to project rice fields. The dependent variable in the model is 1 or 0 (1 if a female farmer in the sample has her own rice field in the project). The qualitative response model is estimated, using Newton's method—that is, the variance matrix for the coefficients is estimated with the second derivatives of the log-likelihood.²³ There are 463 women included in this analysis. The model hypothesizes that women's access to new technology is determined by the socioeconomic and lineage characteristics of their compound and by their own individual status within the compound. The results of this analysis (see Table 8) are as follows:

- Women of higher status, that is, older women and *sinkiro* heads (who are usually first wives of compound heads), had a significantly higher probability of obtaining a field (variables 1, 2, and 3, Table 8).

²³ The program LIMDEP was used for estimation; see Greene (1986, 19.3-19.10) and Maddala (1983).

Table 8—Determinants of access of individual women to fields in the project (probit estimate)

Explanatory Variable	Estimated Parameter	t-Value	Change in Probability of Having Access to Field ^a
(1) Age of women ^b	-0.9847E-1	-8.39	-0.039
(2) Age of women squared	0.1232E-2	6.81	+0.005
(3) Woman is <i>sinkiro</i> head	0.8733	4.82	+0.350
(4) Woman is married to compound head	0.1471	0.78	...
(5) Woman was traditional rice grower ^c	0.4827	2.64	-0.200
(6) Number of women in compound ^d	-0.3610E-2	-2.52	-0.001
(7) Compound has more than one <i>sinkiro</i>	-0.1703	-0.95	...
(8) Size of land in project for whole compound ^e	0.7353	3.99	+0.290
Number of observations	463	...	...
Chi-squared	40.02	...	...

Note: Dependent variable—if a woman had her own field in the project or shared one with other women (= 1, else = 0).

^a The probability is approximated from the estimated parameter by multiplying with the factor of 0.4 following an approximation approach described in Takeshi Amemiya, "Qualitative Response Models: A Survey," *Journal of Economic Literature* 19 (December 1981): 1483-1536.

^b Age in years.

^c Dummy variable = 1, if a woman had her own rice field in the area before the project and a personal rice store.

^d Number of women of working age in the compound.

^e Amount of project rice land in hectares expressed in irrigated land equivalent (for the whole compound).

• Traditional rice growers, defined as having had both a field and a personal rice store before the project, also had a significantly increased probability of obtaining a field (by 22 percent, variable 5); thus, traditional rice-growing women were protected to a certain extent by the distribution.

• Land allocation was carried out to the relative disadvantage of women in large compounds inhabited by many women (variable 6).

• The greater the amount of project land allocated to a compound, the higher is the probability of a woman in that compound gaining access to some of that land (variable 8).

To sum up this section, access to new rice land was widely distributed across the communities in the project region. At compound level, no apparent maldistribution by preproject resource endowments occurred. Ethnicity played a role in gaining access, partly as a result of different specializations of ethnic groups in economic activities and within agriculture. Contrary to the intent of the project, women were not the primary beneficiaries of the fully water-controlled land, but they did gain access to the partly water-controlled land. Among women alone, status characteristics were important in determining access to the improved rice land.

Technology Levels, Yields, and Control Over Cro

Much of the rice land in the Jahally-Pacharr project is used for growing a communal (household) crop. This is true for nearly all of the fully water-controlled land and for a substantial share of the tidal and rainfed plots (Table 9). The traditional upland cereals are also largely grown as communal (*maruo*) crops, while most of the cash crops (groundnuts and cotton) and swamp rice are grown as private (*kamangyango*) crops. Each upland communal field is under the responsibility of a man (usually the compound head), while the communal rice crop is customarily controlled by a woman.

Table 9—Use of communal and private fields in sample compounds, by crop and technology, wet season 1985

Crop	Overall Share of Land Use	Communal (Maruo)	Private (Kamangyango)		
			Total	Men	Women
	(percent)		(percent of hectares of crop)		
Fully water-controlled rice in project ^a	5.8	99.0	1.0	1.0	...
Partly water-controlled rice in project ^b	4.1	87.0	13.0	3.0	10.0
Pump-irrigated rice in old schemes ^c	0.5	67.0	33.0	...	33.0
Swamp rice	10.7	17.0	83.0	6.0	77.0
Early millet	23.1	82.0	18.0	14.0	4.0
Late millet	1.1	81.0	19.0	14.0	5.0
Sorghum	4.2	88.0	12.0	12.0	...
Maize	9.1	92.0	8.0	8.0	...
Groundnuts	37.0	18.0	82.0	59.0	23.0
Cotton	4.5	15.0	85.0	59.0	26.0
All crops	100.0 ^d	51.0	49.0	30.0	19.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^d Parts do not add to total because of rounding.

Women's control over rice fields declines according to yield (technology) levels in the various types of rice production (Table 10). This changing pattern of female responsibility for rice is, however, not simply a switch from a "women's crop" to a "men's crop," but a switch from a mixed communal food/private cash crop, grown mainly by women, to an almost purely communal crop under the responsibility of the (male) compound head.

A close look at the few cases ($n = 17$) of women who actually got access to fully water-controlled rice reveals that these are special cases. One woman is the wife of a

Table 10—Wet season yield levels and female control of rice fields, by technology, 1984 and 1985

Technology	Average Yield		Fields Under Control of Women	
	1984	1985	1984	1985
	(metric tons/hectare)		(percent)	
Fully water-controlled rice in project ^a	6.6	5.2	14	10
Pump-irrigated rice in old schemes ^b	2.9	2.4	54	68
Partly water-controlled rice in project ^c	2.2	2.8	70	77
Swamp rice	1.3	1.3	95	91

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

compound head who is a blacksmith, another's husband is a dry fish trader, a third is the wife of a shopkeeper. In some cases the compound head is rather old or unable to work or has recently passed away and the new compound head is a young boy, and in others the compound head is absent for an extended time. In all of these cases, the fully water-controlled land in the project is used by the senior women as communal land. This occurs even when the same women formerly cultivated their swamp rice as *kamangyango*. The project land thus serves to provide the staple food for consumption in these compounds. The rice crop from the fully water-controlled fields (which provide the highest yield per unit of land) is the one that is most completely transformed into a communal crop (99 percent, Table 9). The relative security of production from these fields and the drought conditions in the area in 1983-85 are important determinants of this.

Yet, while cross-sectional variation of the yields of this rice crop was low (0.27 in 1985, Table 11), yields in the rice perimeter with full water control (pump irrigation) do not appear stable over time. From 1984 to 1985, average yields in the wet season dropped from 6.6 to 5.2 tons, and a reduction occurred also in the 1986 dry season

Table 11—Yields of major crops and variances of yields in the sample, by season, 1984-86

Crop	Yield ^a			
	Wet Season		Dry Season	
	1984	1985	1985	1986
	(kilograms/hectare)			
Fully water controlled rice in project ^b	6,552 (0.24)	5,171 (0.27)	6,488 (0.27)	5,072 ^c
Partly water-controlled rice in project ^d	2,187 (0.73)	2,797 (0.54)	...	...
Pump-irrigated rice in old schemes ^e	2,862 (1.03)	2,362 (0.97)	2,471 (0.59)	...
Swamp rice	1,274 (0.77)	1,277 (0.77)	...	...
Early millet	855 (0.82)	1,103 (0.80)	...	...
Late millet	760 (1.16)	1,127 (1.14)	...	...
Sorghum	197 (1.17)	259 (0.92)	...	...
Maize	402 (1.56)	616 (1.16)	...	...
Groundnuts	1,244 (0.73)	1,214 (0.65)	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Numbers in parentheses represent coefficients of variation.

^a The yields are from fields harvested; yields per hectare of land sown are less in the case of upland cereals and groundnuts, especially in 1984, due to drought effects.

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c Based on a subsample of only 10 percent of households.

^d These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^e These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

(1986 dry-season data are based on a subsample only). The reduction in yields in the wet season is apparently a consequence of increased competition for scarce labor in upland crops. This issue will be addressed below.

Effects of Project on Labor in Subsistence and Cash Crops

Given the average input of 349 person days per hectare per season, the pump-irrigated fields in the fully water-controlled part of the project require 61 percent more labor per hectare than does swamp rice (Table 12). This is the case even though many of the necessary land preparation activities are centrally provided to farmers by the project. Hired labor, usually paid in cash, makes up a substantial share (25 percent) of the total labor input to fully water-controlled fields and 11 percent of the labor input to partly water-controlled fields. Among other crops, 9 percent of the labor input for cotton production is met by hired labor, 6 percent for groundnuts, and 2-3 percent for upland cereals. The recent expansion of the market for hired labor in rice, which hardly existed before, is clearly associated with the new project.

A central question frequently asked is, "To what extent is the shift between men and women in responsibility for crops (fields) also reflected in a transfer of labor between crops?" Or, more specifically, "Do women now perform much of the work on the male-controlled communal rice fields, whereas before they were working for income or food under their own control in their individual rice fields?" In answer to the first question, the share of women's labor in total family labor for the four different rice technologies generally follows the pattern observed for responsibility over fields. Therefore, the answer to the second question is generally no. In swamp rice, where women are responsible for 91 percent of fields, they provided 77 percent of the family

Table 12—Hired and family labor input per hectare, by crop and technology, wet season 1985

Crop	Total Labor	Total Hired Labor	Total Family Labor ^a	Family Labor ^a		
				Men	Women	Children
				(percent of family labor)		
	(person-days/ hectare)	(percent of total labor)		(percent of family labor)		
Fully water-controlled rice in project ^b	349	25	75	69	29	2
Partly water-controlled rice in project ^c	262	11	89	39	60	1
Pump-irrigated rice in old schemes ^d	377	7	93	24	68	8
Swamp rice	217	5	95	17	77	6
Early millet	95	3	97	83	10	7
Late millet	84	2	98	91	3	6
Sorghum	87	3	97	95	1	4
Maize	90	3	97	80	9	11
Groundnuts	141	6	94	69	26	5
Cotton	132	9	91	57	39	4
Total average	...	7	93	62	32	6

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Strange Farmers are included in family labor, since they are not paid in cash and reside within the compounds for an extended period.

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^d These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

labor in 1985. In the fully water-controlled fields of the project, of which women control 10 percent, they provided 29 percent of the family labor input (Table 12). The two other types of rice technologies range between these two extremes.

The close correlation between responsibility for crop production and labor input by sex for that crop also appears in the upland crops. Women do little work in the upland cereals when they are not responsible for them, and their input into groundnuts and cotton is about the same as the corresponding share of land under their responsibility. For instance, women provide 26 percent of all family labor in groundnuts, and their fields cover 27 percent of the total groundnut area in the sample.

In the wider picture of division of labor, women provide 32 percent of all family labor in this sample for the major field crops and men provide 62 percent (Table 12). Although general discussions frequently assume higher figures for women's labor in agriculture in Africa, this finding is in line with results from other detailed studies on women's labor input in West African agriculture.²⁴

Earlier research on rice in this location, with less coverage of ethnic groups and agroecological settings, found much rigidity of sexual division of labor by crop (Dey 1982). The present study indicates that the men provide 17 percent of all family labor to swamp rice production, which is almost exclusively a women's crop. At the same time, women are responsible for 29 percent of all private groundnut and cotton production, and men also provide considerable amounts of labor on these private upland fields.

With regard to ethnic differences, there are indeed substantial differences within this sample. In the upland villages, the Fula and Wolof ethnic groups predominate, while Mandinka and Serahuli are the majority groups in the lowland villages. Upland villages, which are farther away from the new rice land, use more hired labor in their project fields (29 percent), and very little of the project work is done by women (8 percent). Women from these villages, who are not traditional rice farmers, work to a greater extent in upland cereals (15 percent) and in groundnuts (34 percent).

There exists a fair amount of labor-sharing between women and men. Twenty-four percent of the work in the fully water-controlled fields that are under male control is accounted for by hired labor; the remaining 76 percent is family labor, of which 26 percent is provided by women. The few women who are responsible for a rice field of this type use more hired labor (35 percent) and provide more of the total family labor to such fields themselves (51 percent). In Table 13 the division of labor is presented for all fields separately by communal and individual organization. In general, it is found that when a field is under communal organization and controlled by a man (usually the compound head), most of the family labor input comes from men. This is least pronounced in the case of partly water-controlled rice, which is generally more of a "women's crop." But apart from this case, men contribute 72-86 percent of family labor in the communal fields that are male-controlled. In general, this pattern holds true also for communal fields controlled by women. Here women provide most of the field labor, but with the exception of traditional rice, this pattern is not so pronounced as in the case of male-controlled communal fields.

A fair amount of labor-sharing occurs in individual fields controlled by women, especially in the cash crops—groundnuts and cotton. Women receive a substantial share of family labor input from men in their own mostly private (*kamangyango*) fields. In women's own groundnut fields, for instance, women provide 48 percent of the family labor, while 47 percent comes from men, who are usually their husbands.

²⁴ For a review and a more specific evaluation of this issue, see von Braun and Webb (1989).

Table 13—Division of labor between men and women in communal and individual farming, by crop, wet season 1985

Crop	Organization	Share of Family Labor ^a					
		Fields Controlled by Men			Fields Controlled by Women		
		Number in Sample	Men	Women	Number in Sample	Men	Women
			(percent)			(percent)	
Fully water-controlled rice in project ^b	Communal	155	72	26	18	44	51
	Individual	...	...	...	...	...	...
Partly water-controlled rice in project ^c	Communal	23	62	37	61	29	70
	Individual	...	...	...	16	40	59
Swamp rice	Communal	...	...	...	30	4	86
	Individual	24	58	38	245	14	80
Early millet	Communal	209	86	8	...	...	...
	Individual	67	86	5	22	56	40
Groundnuts	Communal	79	86	7	...	...	...
	Individual	308	82	13	241	47	48
Cotton	Communal	...	...	...	...	...	...
	Individual	43	73	22	27	27	71

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a The child labor share is not listed, so respective figures do not add up to 100. Cases with less than 10 observations in the sample are not listed.

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

The next question to be addressed is, "What is the total agricultural workload of men and women farmers and how did it change under the new rice project?" The marked seasonality of rainfed agriculture does not permit continuous work in the fields. Of total available workdays—about 165 days over the entire wet season—men spend 70 percent and women 36 percent in field crop production (including related preparation and transportation activities). In the dry season, men spend 24 percent and women 13 percent of available time in irrigated rice work. Overall, men in lowland villages of the project area spend a lower share of their time in crop production than men in upland villages (62 percent versus 84 percent in the wet season), but the opposite is true for women (39 percent in the lowland versus 32 percent in the upland villages). Women's work in rice is a main factor in determining this difference. Yet, although labor allocation differs widely by crop between upland and lowland villages and between men and women, the total time spent in agriculture is similar—52 and 57 percent, respectively, of available time in the wet season. It should be stressed that during the wet season there are various labor peaks, especially at times of upland crop weeding and rice transplanting.

The new rice project provides additional employment, particularly in the dry season when there is underemployment, and it induces a substitution effect between work on other crops and work on the new rice fields during the wet season. This is demonstrated in Table 14, where households are grouped by the amount of new rice land available per adult-equivalent person. In the dry season, women and men in the lowest quartile spend 3 percent and 11 percent, respectively, of their time in agriculture, while in the highest quartile they spend 24 percent and 36 percent, respectively.

Table 14—Allocation of men's and women's labor to major crops, by amount of project land cropped per household, 1985

Amount of Land in Rice Project ^a	Time Spent on Crop as Share of Total Available Labor Time in Season				Total
	Dry Season	Wet Season			
		Rice	Millet and Maize	Groundnuts and Cotton	
(percent)					
Men					
Lowest quartile	11	7	31	39	77
Second quartile	19	18	30	32	80
Third quartile	27	23	21	23	67
Highest quartile	36	29	16	13	58
Average (all men)	24	17	25	28	70
Women					
Lowest quartile	3	9	6	19	33
Second quartile	8	25	4	12	40
Third quartile	15	27	1	7	36
Highest quartile	24	33	...	4	38
Average (all women)	13	23	3	11	36

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

^a The quartiles are formed on the basis of amount of land per capita in "irrigated land equivalent area" (area is weighted based on yields in the different technologies in the project area). Mean yields are used as constant weights, so are not influenced by variations in plot-specific land quality (drainage) and input levels.

With increased availability of project rice land, wet season work patterns by men and women show strikingly different tendencies. Men's total work in agriculture decreases from 77 percent to 58 percent of available time (from 127 to 96 days), while women's total work increases slightly (Table 14, last column). This may point to a "leisure" effect for men, or to increased nonfarm work, which is apparently not shared with women. This question is addressed later in a more refined analysis of the reallocation of labor between crops.

It appears that the expansion of men's labor in rice (Table 14, column 2), which results in higher absolute returns per day of work for this communal crop, is accompanied by a higher absolute reduction in labor inputs to the upland crops than in the case of women (Table 14, columns 3 and 4).

The substitution effects between new rice fields and upland crops and swamp rice in an environment of land surplus (in the upland and swamp areas) are mediated through the competition between crops for scarce labor. However, this competition is also reflected in the resultant land-use patterns. In order to assess this, it was possible to draw on longitudinal information obtained in careful recall surveys on a field-by-field basis with the survey farmers. The aggregate results show that total land area cultivated, including the new rice fields, expanded from 1983 to 1985 (the 1984 area increased by 6 percent over 1983 and in 1985 the area was 3 percent larger than in 1983). The area under all other crops dropped by 8 percent (Table 15). In general, this is due to the reduced upland crop production (-10 percent of area) rather than reduced traditional rice production, which declined only for an intermediate year but actually rose again in 1985. As one would expect, those compounds that received large pieces of land in the project most reduced the area of upland crop and swamp rice that they cultivated between 1983 and 1985 (by 27 percent). Conversely, compounds in the lowest quartile (of rice land per adult equivalent) actually expanded the land under all nonproject crops by 7 percent in the same period.

Table 15—Changes in land use by sample households under the new project, by amount of rice land cropped, 1983-85

Household Quartiles of Project Rice Land per Adult-Equivalent Person	Area of Upland Crops and Traditional Rice			
	Hectares in Whole Sample	Index 1983 = 100		
		1983	1984	1985
Lowest quartile	283	100	108	107
Second quartile	216	100	97	93
Third quartile	185	100	88	81
Highest quartile	110	100	74	73
Total	794	100	96	92

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Production Organization and Profitability of Different Technologies

Obviously, there is an opportunity cost for the labor pulled away from the upland crops and swamp rice into the new rice fields. If the difference between the opportunity cost of labor established by the net returns to wet-season upland work and actual net returns to the new fields is small, the net benefit to participants and society will be small (as long as the land-abundant situation prevails in the area). To address this critical issue, a gross margin calculation is performed on a field-by-field basis for the whole sample for all major crops. Gross margin refers to the output product multiplied by the sales price (if nothing was sold, the village-specific average market price for that commodity was used) minus all variable input costs, including seed, fertilizer, hired labor, and other inputs such as charges for water and tractor-powered land preparation in the rice project. The gross margins are then related to unpaid (family) labor and to field size. Mean values of the computations and their coefficients of variation are presented for all major crops in Table 16. It should be noted that these are private returns, not economic (social) returns. The rice production in the project includes a substantial subsidy element, as discussed in Chapter 3.

The average labor productivity in the fully water-controlled rice fields is by far the highest, at D14.70 per person-day. This rice technology requires about 15 times the variable cost per hectare compared with swamp rice and about three times the variable cost per ton of paddy. The need for financing these variable costs is clearly substantial. A credit facility operating in the project provides financing for fertilizer, seeds, and irrigation. But other costs for transport, hired labor when required, and threshing may be significant, too. On average, the other rice types were less remunerative in 1985 than the traditional upland crops (millet/sorghum and groundnuts). In the partly water-controlled fields, mainly operated by women, labor productivity was only half of that in the fully water-controlled fields, but still 30 percent higher than in swamp rice. It should be noted that returns to labor in upland crops were curtailed in 1985 by an unusual fertilizer shortage in The Gambia that affected the upland crops and traditional rice of the sample farmers but did not affect the rice in the project (von Braun and Puetz 1987). Returns to labor in the upland crops were, therefore, rather below the level of a "normal" year.

A compound head who was able to switch his work force from millet/sorghum production for the common food stock to rice in the fully water-controlled section of

Table 16—Farm-level profitability of rice technologies and major field crops, wet season 1985

Crop/Technology	Average Gross Margins ^a and Their Coefficients of Variation ^b		Variable Costs per Hectare
	Per Person-Day of Family Labor	Per Hectare	
		(dalasi) ^b	
Fully water-controlled rice in project ^c	14.7 (0.87)	2,938 (0.46)	1,766
Partly water-controlled rice in project ^d	7.4 (0.96)	1,371 (0.72)	925
Pump-irrigated rice in old schemes ^e	3.8 (1.48)	1,720 (1.20)	538
Swamp rice	5.7 (0.75)	1,041 (0.81)	122
Millet, sorghum	9.0 (0.89)	731 (0.97)	45
Maize	6.6 (1.30)	495 (1.29)	50
Groundnuts	8.7 (0.87)	943 (0.77)	266
Cotton	3.2 (1.38)	375 (1.47)	92

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

^b Coefficients of variation are in parentheses.

^c These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^d These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^e These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

the project gained D5.70 per workday per person of his work force (D14.70-D9.00). In other words, the communal work force needed to work 39 percent less to obtain a similar return (D5.70/D14.70).

Returns to labor in men's fields are higher than in women's fields. This holds true for the individual crops (groundnuts, cotton, and swamp rice) where both men and women have control, and also for the different technology levels in rice (Table 17). The returns to labor in women's fields (partly water-controlled) are 44 percent below men's (fully water-controlled): 39 percent below men's for swamp rice, 35 percent below for groundnuts, and 49 percent below for cotton. An explanation for these consistent differences requires careful consideration of the input and output side of women's field operations. Lower average labor productivity for women is suggested by women's multiple work load in home activities (with the related organizational problem of timeliness in field operations such as preparation and weeding), reduced ability to make decisions on labor allocations within the household and establish a reliable and enforceable labor-sharing arrangement, and reduced benefits from related scale economies. For instance, women's individual groundnut fields are 50 percent smaller than men's. Unproductive walking time to the fields is, therefore, twice as high per

Table 17—Gross margins per person-day in fields under male control and under female control, wet season 1985

Crop/Technology	Average Gross Margin per Person-Day	
	Men's Fields	Women's Fields
	(dalasi)	
Fully water-controlled rice in project ^a	13.9	b
Partly water-controlled rice in project ^c	b	7.8
Swamp rice	8.9	5.4
Millet, sorghum	9.1	8.0
Maize	6.7	b
Groundnuts	10.0	6.5
Cotton	3.9	2.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b Less than 25 observations and therefore not shown.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

unit of output in women's fields at same yield levels. Women's swamp rice fields tend to be located far from the compound, which results in a high share of working time spent traveling to and from the field. Also, women own far fewer labor-saving implements than men (Table 18). This may be a critical factor in timely use of implements and in breaking labor bottlenecks at times of planting and weeding.

Although the average returns to labor in the fully water-controlled rice in the project substantially exceed the average returns to all other crops, it must be recognized that a substantial number of farmers manage to achieve similar productivity levels in upland crops (see Figure 5). The average return of about D15 per day for fully water-controlled rice is achieved, or even exceeded, by 23 percent of farmers with upland cereals and 17 percent of farmers with groundnuts. The majority of groundnut and millet farmers exceed the average returns per labor day achieved by farmers in the partly water-controlled rice fields of the project.

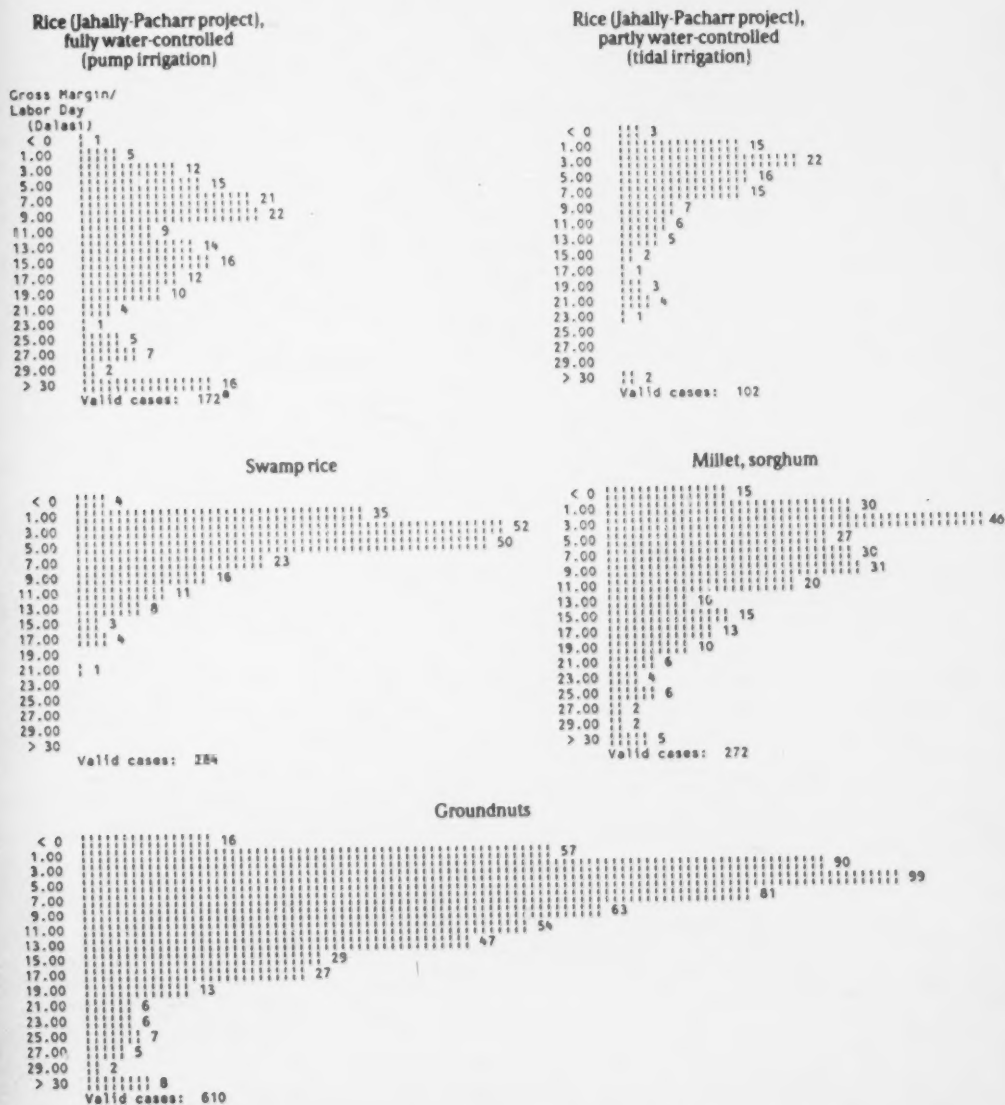
Table 18—Ownership of labor-saving implements by men and women farmers, wet season 1987

Implement	Men	Women
	(percent owning the tool)	
Plow	8.2	0.0
Seeder	26.9	0.6
Weeder	12.4	0.2
Multipurpose implement ^a	18.1	0.4

Source: 1987/88 follow-up survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a An animal-drawn implement convertible for plowing, weeding, and groundnut lifting.

Figure 5—Distributions of returns to labor, by crop, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Cases refer to number of farmers (male and female).

Labor Productivity in New Rice and Traditional Crops

The purpose of the following analysis is to assess the total and marginal opportunity costs of the new rice crops as established by the returns to labor that would otherwise have remained in upland crop and swamp rice production. An assessment is then made of the effects of labor reallocation on food production, manifest in the additional project rice output, which has supplanted a certain amount of production in the upland cereals, upland cash crops, and swamp rice because of competition with labor.

Production Functions

Production functions are estimated to evaluate marginal labor productivity in the various crops. The reallocation of labor induced by the labor demand from the new rice fields is analyzed with the help of labor input functions thereafter (see also conceptual framework in Chapter 2, equations [3] and [4]).

The production functions are specified for main field crops and take the institutional setting, such as communal versus individual field and field under male versus female control, into account and are quadratic in the main inputs to permit decreasing marginal returns.

A note of caution is in order here regarding the general problem of estimating technical input-output relationships on the basis of cross-sectional farm-survey data that are not structured for a strictly controlled experiment. Capturing the factors of variability in managerial skills and in agroecological microconditions poses a particular problem of latent unobserved variables. An attempt was made to take account of these by including variables depicting crop responsibility along gender lines, distance of field from village (the closer ones among upland villages tend to get more manure from grazing animals), and the somewhat better soil conditions in a particular zone among the upland villages along the border to Senegal. The main differences in agroecological conditions are taken into account by separately specifying the production function for the upland areas (soils of sandy detrital sediment of relatively low fertility) and for the lowland areas (hydromorphic soils).

While the main purpose of the production function estimates is to arrive at marginal labor productivity, the authors also want to assess the effects of crop-specific implement use and institutional setting (communal fields, share of fields under women's control) on output. The dependent variable is the total production of the respective crops from communal and individual farming per compound (or compound subunit in the case of some large Wolof and Mandinka compounds) in the wet season of 1985. Slightly modified for the various crops, the production functions have the following formula:

$$Q_{ji} = f[\text{FSIZE}_{ji}, \text{LAB}_{ji}, (\text{LAB}_{ji})^2, \text{FER}_{ji}, (\text{FER}_{ji})^2, \text{TECH}_{ji}, \text{INST}_{ji}, \text{SOIL}_{ji}], \quad (11)$$

where

Q_{ji} = production of crop j on farm i ,

FSIZE_{ji} = size of field(s) in hectares,

LAB_{ji} = total labor input in person-days (paid and unpaid labor) per hectare,

FER_{ji} = fertilizer use per hectare,

TECH_{ji} = set of dummy variables on implements used (see Table 19 for specifics),

INST_{ij} = set of institutional variables (such as communal field, women's fields; see Table 19 for specifics), and

SOIL_{ij} = soil dummy variable for better soils in border zone within upland area.

The estimation results are presented in Table 19. The results are largely consistent with expectations.

Table 19—Production functions of major field crops

Variable ^a	Upland Cereals—Millet, Sorghum, Maize		Groundnuts		Partly Water-Controlled Project Rice and Swamp Rice ^b	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
HAFERT	7.2962	1.54	7.5200	1.97	1.0208	0.29
HAFERTSQ	9.1866E-3	-0.29	-0.0272	-1.18	-1.29542E-0	-0.10
HALAB	10.2583	2.19	7.2779	2.04	8.9287	3.23
HALABSQ	-0.0189	-1.20	-0.0109	-1.28	-0.0127	-2.56
WRKWOMAE	-431.3700	-0.68	-1,113.5900	-1.89	1,210.2085	1.73
MARUOSH	198.4560	0.53	117.0740	0.59	-299.3296	-1.20
WOMENSH	827.9140	1.31	-462.1430	-1.39	304.7832	0.97
SIZEFLD	983.0190	14.78	1,193.1750	23.20	1,545.7655	19.55
DISTANCE	-5.2980	-0.69	1.0661	0.27	-3.1940	-0.68
SINEUSE	173.2760	0.93	-165.4460	2.69	...	...
PLWUSE	-173.9970	-0.95	-829.6420	-1.03	...	...
SOIL	1,021.1590	4.70	441.0320	2.18	...	...
JPSHARE	...	...	...	...	1,392.1316	4.39
Constant	-1,389.2570	-2.54	-723.0742	-1.93	-2,093.7082	-3.38
R ²	0.671		0.821		0.796	
F-value	34.39		72.62		45.59	
Degrees of freedom	184		175		117	

Note: Dependent variables—output of crops per compound, or compound subunit in the case of large Wolof and Mandinka compounds.

^a Definitions of variables in the production function:

- HAFERT = fertilizer applied per hectare in kilograms of material;
- HAFERTSQ = HAFERT squared;
- HALAB = total labor input in person-days per hectare;
- HALABSQ = HALAB squared;
- WRKWOMAE = number of women in household of working age per adult equivalents;
- MARUOSH = share of fields of the crop under communal production (*maruo*);
- WOMENSH = share of fields of the crop under women's control;
- SIZEFLD = size of crop area in hectares;
- DISTANCE = walking distance to field in minutes;
- SINEUSE = multipurpose implement used (= 1, else = 0);
- PLWUSE = plow used (= 1, else = 0);
- SOIL = soil quality dummy within upland area (= 1 if fields close to border area [better soils], else = 0); and
- JPSHARE = share of partly water-controlled land in project over total of tidal, rainfed, and traditional rice.

^b As fully water-controlled rice production in the project does not involve the crop-specific area allocation choice (because of the rationed land distribution), a yield function was estimated for fully water-controlled project rice. Specification and estimation results are as follows:

$$\text{YIELD} = 3,992.9 + 7.1197 \text{ HAFERT} - 0.0124 \text{ HAFERTSQ} + 2.5229 \text{ HALABWE} + 716.23 \text{ SIZEFLD},$$

(8.03)(1.96) (-1.83) (0.74) (1.81)

where YIELD = paddy yield in kilograms per hectare and HALABWE = weeding labor input in person-days per hectare.

The *average* opportunity cost of labor in the new rice fields (established by alternative use in upland crops and traditional rice) has already been defined by the gross margins per labor day in these crops. The estimated production functions are used to compute the *marginal* labor productivity for the various crops. It turns out that marginal returns to labor in upland crops (millet and groundnuts) were higher than in the new rice fields in the wet season of 1985/86 (Table 20). The related parameters in the production functions for the upland crops are largely robust and significant. Marginal labor productivity is lower than average productivity. Yet for the major field crops (groundnuts and upland cereals), it is still D4.60-7.50, or US\$0.91-1.48 per day.

A diagnosed low overall marginal labor productivity in the fully water-controlled rice fields (Table 20)—despite high average labor productivity over the season—does not come as a surprise. Participating farmers are under considerable pressure to adhere to a strict schedule defined by the project's management. This stresses maximum yields rather than equating marginal returns with marginal (opportunity) costs of labor. Farmers not maintaining the set schedule, and therefore achieving "inadequate" yield levels, run the risk of being expelled from the project. Farmers with a very profitable dry-season crop in the fully water-controlled area are unlikely to take that risk. Also, the relatively safer pump-irrigated crop compares favorably with the upland crops in a drought year. From a farmer's perspective, however, and in economic terms, it would have been better to spend more time on the upland crops in 1985/86, given their higher marginal returns to labor. This coincides with a reported reluctance of some farmers to follow the schedules set by the project.

Implications for Irrigation Schemes

An attempt to maximize yields in irrigation schemes without due consideration of labor's opportunity cost is suboptimal both for farmers and for the economy. Irrigation schemes in this volatile environment are destabilized by the fluctuating labor supply as a

Table 20—Average and marginal labor productivity in major crops, wet season 1985/86

Crop	Average Labor Productivity in Gross Margin per Labor Day ^a	Marginal Labor Productivity Derived from Production Functions ^b
	(dalasi/person-day) ^c	
Upland cereals (millet, sorghum, and maize)	8.88	7.50
Groundnuts	8.70	4.61
Swamp rice	5.70	3.20 ^d
Partly water-controlled rice in project ^e	7.40	3.20 ^d
Fully water-controlled rice in project ^f	14.70	1.42 ^g

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

^b The marginal labor productivity evaluated at respective mean values of labor input and average sales prices of output; for parameters, see Table 19.

^c One U.S. dollar equals 5.06 dalasi.

^d Traditional swamp rice and partly water-controlled rice in the project are dealt with in one model (Table 19).

^e These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^f These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^g The parameter on which this value is based is statistically insignificant (see footnote b on Table 19).

consequence of changing returns to labor in competing crops from year to year, which is a function of rainfall quantity and distribution. A flexible response to this situation is required—one that cautiously permits yield fluctuations due to labor reallocation—not an attempt to either enforce constantly high labor input or maintain it by an excessive subsidy to irrigation. Neither is economically justifiable.

In addition, a flexible (economic) approach to yields, which permits the irrigation schemes to fluctuate between lower yields in years of good rainfall (when labor is pulled into upland crops) and higher yields in years of low rainfall, would introduce a buffer function for local- and household-level food security. In the 1984 drought year, the Jahally-Pacharr project in fact functioned that way. Making use of this food security potential of small- and medium-sized irrigation schemes calls for a wide distribution of irrigated land across the communities in order to permit a large number of compounds to resort to irrigated rice with rather stable and high yields, even though achieved at low marginal labor productivity in drought years.

Effects on Labor Allocation and Competition with Other Crops

Given the above patterns of average and marginal returns to labor in rice under new technology versus other crops, what are the implications for and effects on labor allocation? To address this question, a labor input model is specified, as discussed in the conceptual framework (Chapter 2, equation [3]).

Given various demographic characteristics, labor inputs to crops and to nonagricultural work are hypothesized to be determined by relative net returns to labor in the various alternative activities. Only some of these basic relationships can be adequately captured in this cross-sectional analysis. Actual crop prices and farmers' price expectations are excluded because of the cross-sectional nature of the data. The main focus of the labor input analysis is to quantify the effect of access to project rice land on labor inputs to other crops. Household demographics are assumed to play a role here, as some ethnic and gender specificity of labor allocation by crop occurs. In addition, the project's labor-saving capital equipment may affect the degree of substitution between the new rice crop and other crops grown before. The crop-specific and aggregate labor input functions have the following formula:

$$LAB_{ji} = f(DEM_{ji}, LOC_i, CAP_i, RLAN_i), \quad (12)$$

where

LAB_{ji} = total labor input in person-days (paid and unpaid labor) for crop j by farm i ,

DEM_{ji} = a set of demographic variables (household size, children, women's share),

LOC_i = distance from project in terms of location of village in upland or lowland,

CAP_i = value of agricultural machine and implement capital stock per adult-equivalent person, and

$RLAN_i$ = size of area in the rice project per adult equivalent (in fully water-controlled equivalent area).

The results are presented in Table 21. The model further supports the impression from earlier tabulations that with increased availability of rice land in the project, total

Table 21—Reallocation of labor between crops: regression results

Explanatory Variable	Family Labor in All Crops		Family Labor in Upland Cereals		Family Labor in Groundnuts		Family Labor in Swamp Rice	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
Size of compound in adult equivalents	46.507	17.13	8.281	8.17	15.129	10.37	18.342	9.48
Number of children under 10 per adult equivalent	-331.021	-3.51	-58.359	-1.62	-117.043	-2.12	-72.728	-1.00
Ratio of women per adult equivalent	60.012	0.50	-47.900	-0.95	-71.842	-0.94	184.418	2.17
Location of village (1 = lowlands, 0 = uplands)	-27.989	-0.76	-68.134	-4.93	-141.641	-7.09	138.591	2.60
Machine and implement capital per adult equivalent (dalasi)	0.6672	0.72	0.2039	0.56	-0.3096	-0.62	0.4041	0.61
Amount of land in project per adult equivalent (hectares) ^a	-942.980	-1.71	-684.048	-3.18	-1,045.305	-3.04	-855.950	-2.20
Constant	200.949	3.00	157.716	6.04	227.238	5.88	-150.904	-2.28
R ²	0.614		0.420		0.556		0.508	
F-value	55.900		24.780		38.540		18.730	
Degrees of freedom	202		184		174		97	

Note: Dependent variables—family labor input in person-days by respective crop at compound level, except in the case of large Wolof and Mandinka compounds, where subcompound units are used.

^a Land expressed in "fully water-controlled equivalent" on yield basis.

labor input in agriculture is decreased rather than increased. The estimated parameter (Table 21, column 1) of -942.98 suggests that if an average compound obtains an average portion of project land (0.43 hectare), total labor inputs to agriculture are reduced by 28 days per compound, or 7.5 percent of total wet-season labor. Note that the parameter is not of high statistical significance. From the above tabulations, it was evident that it was more male than female labor input that was reduced overall (see Table 14).

More significant than this labor-input-reducing effect, which could include a "leisure effect" arising out of the income effect of the more profitable new rice fields, are the labor substitution effects to the various crops. Evaluated at the respective sample means, given access to an average piece of project land, total labor to swamp rice is reduced by 21 percent; to upland cereals, by 19 percent; and to groundnuts, by 22 percent. Clearly, the competition between labor for the new rice and labor for the upland crops and traditional rice is strong.

The opportunity cost of labor in the project has profound implications for the net benefits of technological change and its related investment. The reduction in upland cereals and groundnuts due to reduced labor allocation to these crops is crucial. The output volume of the principal nonproject crops was reduced by 19.4 percent for an average compound (Table 22). The gross income forgone due to reduced crop production outside the project amounts to D636 per compound or compound subunit in the large Wolof or Mandinka compounds.

In terms of each ton of incrementally produced paddy, this output forgone in other crops is equivalent to 161 kilograms of upland cereals, 112 kilograms of swamp rice, and 204 kilograms of groundnuts. For every incremental D100 earned in the new rice production in the wet season, D64 are lost from other crop production.

To sum up insights from this chapter, staple food supply *is* increased to the households, but at considerable cost. These costs consist of investment costs and direct operating costs in the project, and of output forgone in the other crops from which labor was withdrawn. This last cost component is frequently overlooked. The challenge for program and project design and management is to select and promote technologies at the microlevel that will enhance labor productivity. A simple focus on a high and

Table 22—Opportunity cost of project rice and production forgone from other crops due to project

Forgone Income/Production	Change per Compound ^a			Total Weighted Average
	Upland Cereals	Swamp Rice	Ground-nuts	
Gross income forgone (at average net returns per person-day, in dalasi) ^b	246	194	383	636
Crop production forgone Kilograms/compound ^c	289	201	368	...
Percent of 1985 production of each crop	19.3	38.0	17.5	19.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Average compound at sample means.

^b Computed on the basis of the gross margin computation (Table 16) and the labor input functions (Table 21).

^c Computed on the basis of the production functions (marginal labor productivities: parameters of HALAB, HALABSO) and the labor input functions (Tables 19 and 21).

stable output per unit of land can easily be misleading in this West African environment. A flexible approach to yields in such irrigation perimeters is required, guided more by overall economic considerations and less by ease of project management. This would make optimal use of scarce farm labor but would not respond with excessive subsidies or enforcement of power when labor follows economic incentives and turns away from irrigated rice in years of good rainfall that enhance returns to labor in the uplands.

EFFECTS ON MARKETED SURPLUS, STORAGE, AND INCOME

For a complete assessment of the effects of new agricultural technology on different population groups, an analysis of the demand-side effects of the increased output is as important as one for the supply-side effects. This chapter, therefore, evaluates the effects of technological change and commercialization on marketed surplus and income, while the following chapter considers the consumption of food and nonfood resources.

Marketed Surplus Effects

Cereals produced by the household are used for a variety of purposes. On the disappearance side of the balance, sales for cash are only one among many transactions, some of which constitute in-kind payments. Among these in-kind transactions are loan repayments, payment for hired labor and the renting of tools, and various types of gifts and donations. A broadened view of "marketed surplus" is required in this social environment, where gifts and donations form a large part of transactions related to a complex system of social security. Gifts may take the form of goods traded against services and may also be "true" charitable donations, bearing in mind that there is a strong obligation in this society for the receiver to repay "gifts" whenever the giver falls into a time of need (Mauss 1954).

The various uses of a harvest differ a great deal between crops and types of technologies of crop production. In the case of rice, the highest share (about 20 percent) of cash sales is observed for the swamp rice (Table 23), while only 7-12 percent of project pump-irrigated rice was sold. Thus, an inverse relationship between levels of output per unit of land and labor and percent of marketed surplus of rice is observed here. This has little to do with technology as such, deriving instead from the institutional arrangements under which each crop is produced. As discussed above, rice in the project is largely a communal crop, of which little is sold. Swamp rice, on the other hand, is a women's crop grown partly for food and partly for cash income. Similarly, very little is sold of the upland cereals (millets, maize), which are also largely grown as communal crops.

The importance of the institutional arrangements is particularly significant for the rice crops: 80 percent of swamp rice cultivated as *maruo* was actually consumed in the *sinkiro*, compared with only 58 percent of the *kamangyango* swamp rice. Similarly, we find that from the partly water-controlled rice in the project, 45 percent was retained for consumption when grown as *maruo*, but only 19 percent when grown as a *kamangyango* crop in 1984/85.

Rice cultivation in the project involves loan repayments for inputs and water charges. In 1984 these amounted to 30.1 percent of total output, but they dropped to 18.3 percent in 1985 in the fully water-controlled rice. The drop was due to upwardly adjusted output prices applied to the per-unit-of-land repayment duties. This portion of "marketed surplus" required for loan repayment is a quota and not a choice variable on the part of the farmers. Nevertheless, from a sectoral perspective it still indicates an increased commercialization of agriculture. After the disposal components of loan

Table 23—Uses of harvest, by crop and rice technology, 1984 and 1985 wet seasons

Use	Rice									
	Fully Water Controlled in Project ^a		Partly Water Controlled in Project ^b		Pump Irrigated in Old Schemes ^c		Swamp		Early Millet, Sorghum	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
Loan repayments	30.1	18.3	34.2	27.2	5.7	4.4	0.4	0.8	0.2	0.2
Hired labor and rents ^d	1.4	0.7	1.6	2.7	3.1	2.5	2.6	1.5	0.4	0.3
Gifts, donations	6.5	9.4	5.8	10.7	9.3	11.5	10.7	15.4	10.4	12.7
Sale ^e	7.3	12.2	15.5	6.9	8.2	2.1	19.1	20.7	2.9	0.9
Consumption ^f	54.7	60.2	42.9	52.5	73.7	79.5	67.2	61.6	86.3	85.9
									82.8	85.5
									22.5	29.0

(percent of total production of each crop)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^d For implement rentals (in-kind repayments).

^e Including harvest given as loans for later payment (0.1-0.4 percent per crop) and exchanged in kind (barter, 0.0-0.2 percent per crop).

^f Including retained seed (1.3-5.4 percent of cereals, 10.9 percent of groundnuts) and storage losses, which are negligible on average.

repayments and some project cost recovery (the "water charges") are accounted for, the share of project rice marketed is smaller than that of swamp rice.

Nevertheless, the proportion of all rice marketed is generally higher than that of coarse grains (Table 23). Nearly all of the coarse grain produce stays in the compound, apart from donations, of which the traditional charity donation called *zakat* (a decile of the harvest) forms the largest share. Fluctuations in domestic household cereal supply and in demand (stemming from seasonal and interyear fluctuations in coarse grain production) are largely leveled out by transactions in rice. Thus it is the rice market in rural areas that equates effective demand with the general supply of cereals. In the 1984/85 year of drought and trade-determined cereal shortfalls, the marketed surplus of millet was slightly higher than in 1985/86. Yet, even in upland villages that concentrate on millet production, sales did not exceed 7 percent of total output.

In general, women farmers sell a higher share of rice produced under their control than men in the same rice technology (Table 24). Women use rice as a means to raise cash for the purchase of, for example, cooking ingredients, which are important female expenditure items. Rice sales from stocks are frequently carried out in small quantities "by the cup."²⁵ In the wet (hungry) season when most compound stocks are low, these sales are important both for the sellers (who raise cash for the purchase of ingredients) and for the purchasers. The latter are particularly short of cash during the hungry season, and they bridge this period with short-term purchases tailored to the specific circumstances of the household's ability to purchase and the timing of the first September grain harvests (roasted fresh maize cobs, fire-dried early millet).

Most by-the-cup selling is done by women. On average, women in the sample sold 2.6 kilograms of rice per week in this invisible market in the wet season. These sales correspond to 9 kilograms of paddy per *sinkiro* per week in the 55 percent of *sinkiros*

Table 24—Shares of rice harvest retained for consumption and sold, by technology and sex of farmers, 1984 and 1985

Use	Fully Water-Controlled Rice in Project ^a			Partly Water-Controlled Rice in Project ^b		Pump-Irrigated Rice in Old Schemes ^c			Swamp Rice	
	1984	1985		1984	1985	1984	1985		1984	1985
	Wet Season	Dry Season	Wet Season	Wet Season	Wet Season	Wet Season	Dry Season	Wet Season	Wet Season	Wet Season
	(percent)									
Retained for consumption										
Men	54	58	59	72	61	81	67	71	62	68
Women	51	55	60	32	51	61	75	82	64	61
Sold										
Men	7	7	11	...	7	3	10	5	16	15
Women	7	9	19	18	7	12	5	0	18	21

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Other uses of the harvest are not included; therefore, figures do not add up to 100 (see Table 23).

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

²⁵ Standard-sized tins are used for measurement. The most frequently used tin holds about 250 grams of white dehusked rice.

reporting such sales. Most of these *sinkiros* (80 percent) are in lowland villages and these sales stem largely from the dry-season crop cultivated in the fully water-controlled part of the Jahally-Pacharr project. The irrigated dry-season crop serves to even out the most severe seasonal scarcities in cereal availability. The by-the-cup sales between July and September add up to about 8 percent of the dry-season paddy harvest.

The effects of the new rice technology and the heterogeneity of cereal sales by type of farm household become more apparent if the sample is divided by lowland and upland villages and by degree of access to new project rice fields. Generally, the more the involvement in the project, the more sales of rice increase as a proportion of production (Table 25). Among compounds with a high degree of involvement in the project, the share of sales from women's swamp rice increases even more than the

Table 25—Shares of marketed surplus and own consumption of crops, by access to project rice fields, wet season 1985

Crop	Access to Rice Fields in Lowland Villages				Access to Rice Fields in Upland Villages			
	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
(percent of production of each crop)								
Rice								
Fully water controlled in project ^a								
Sales	8.8	5.1	10.8	17.5	4.1	4.3	4.5	0.0
Loan repayment	25.3	17.8	17.0	15.3	17.8	18.5	25.4	25.6
Own consumption	48.4	59.5	58.5	53.8	70.6	64.3	58.5	66.7
Partly water controlled in project ^b								
Sales	6.2	7.5	5.0	8.5	3.5	4.6	c	c
Loan repayment	17.0	22.2	28.1	31.3	26.6	25.6	c	c
Own consumption	62.7	58.2	47.5	40.7	58.4	57.0	c	c
Swamp								
Sales	15.2	18.5	24.0	29.2	8.2	0.0	c	c
Own consumption	57.9	54.5	51.0	51.8	78.7	79.5	c	c
Early millet								
Sales	1.4	0.0	0.0	0.0	1.3	7.0	4.3	c
Own consumption	80.5	88.6	84.5	76.8	84.9	82.5	71.0	c
Late millet								
Sales	c	0.0	0.0	c	7.5	c	c	c
Own consumption	c	88.0	87.0	c	69.4	c	c	c
Sorghum								
Sales	0.0	0.0	0.0	c	0.0	0.0	0.0	c
Own consumption	79.0	90.0	86.5	c	86.9	87.8	76.4	c
Maize								
Sales	8.8	3.5	0.0	0.0	3.3	1.8	0.9	0.0
Own consumption	48.4	70.5	67.7	67.1	86.2	78.3	76.7	82.9
Groundnuts								
Sales	65.0	65.3	51.6	55.1	68.7	63.8	54.8	51.5
Own consumption ^d	21.5	27.8	39.9	35.1	25.8	30.7	34.9	42.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: The quartiles are defined in terms of fully water-controlled area per adult-equivalent person in the *sinkiro* and are formed equally for the whole sample. Thus, for instance, the second quartiles in both upland and lowland villages are formed of *sinkiros* of the same quantity of land per adult equivalent on average.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c No observation.

^d Own consumption includes storage of seed intended for use in the next season, which is a sizable share of these groundnuts.

sales from the project rice. These tendencies come out clearly among the lowland villages, which were traditional rice tillers before the project.

Groundnuts are both a cash and a subsistence food crop. In the lowland villages, and in households with considerable access to new rice fields, 35-40 percent of groundnut production is retained. This traditional cash crop—reduced in area and output due to labor reallocation to rice—is more of a subsistence food crop in such households, while rice has become more of a cash crop. The variable pattern of crop use within the sample, given different family and farm characteristics, underlines the limitations of the simplifying terms “subsistence food crop” and “cash crop.” These tendencies are similar in upland villages, although very little of the rice is sold in them (Table 25).

Increased market integration of agriculture is inseparable from rural development, which exploits the benefits of specialization in an expanding agricultural sector and rural economy. The above analysis highlights the complex patterns of cereal markets at the local and compound levels. Economic factors, environmental conditions, and institutional forces all influence the marketed surplus ratio of cereals. Increased output achieved through technological change in one crop does not lead to a straightforward expansion of marketed surplus. Substitution effects in production and increased consumption—desired from a nutritional perspective by many families—reduce the expected marketed surplus effects of output growth in the new rice crops. A model is used below to further evaluate the roles played by factors that shape the gross marketed surplus of cereals. The model analysis focuses on the effects of increased cereal production for sales of grain and on its short-term price elasticity (see also the conceptual framework in Chapter 2, equation [5]).

The dependent variable in the model is the quantity sold of all cereals (CERSOLD). The cereal quantities are expressed in milled equivalents out of the sum of millet, sorghum, maize, and rice. The model is specified following the hypotheses below.

It is hypothesized that an increased supply of cereals from own production (CERPROD) increases the marketed surplus. While this is certainly the case once household demand is fulfilled (accounted for by size of compound, SIZE), this demand itself can be assumed to be income-elastic. This is accounted for by the per capita income variable in the model (INCOME) approximated by the total expenditure value (cash and in kind) per adult-equivalent person.

From an increased price, an increase in marketed surplus is expected. Because of the dominance of rice in equating supply and demand on the cereals market, and the close correlation with other cereal prices, the rice price (PRICE) is used as the only price variable in the model. Price variability in the cross-sectional sample covering the 1985 season is substantial. This variability stems from local differences in linkages to market outlets and intraseasonal differences that are not independent of demand from across the border (to Senegal) as well as the related exchange rate differences that impinge on the dalasi price. To avoid disturbances in the price variable due to household-specific differences in sales timing (for instance, the poor may be selling earlier in the season at a lower price), village mean prices are used in the model. The logarithm of the price is used, assuming that the price elasticity of marketed surplus is diminishing for larger price changes.

The scope for price policy to stimulate marketed surplus at current levels of infrastructure is of interest for policy analysis purposes. Infrastructure is therefore controlled for in the model with the variable depicting distance to the main markets from each village (DISTANCE). This distance variable is included because time and transport costs to compounds that sell in bulk may not be fully captured by the village-level prices. A

potential endogeneity problem arises where local prices are partly a function of infrastructure, yet the other factors leading to village-specific price variability are also important. The potential endogeneity of prices is certainly an issue that calls for further research in these complex market environments of West Africa.

Given the dominance of rice in the grain market, an increase in the share of rice production in total cereal production (RICESH) is expected to result in an increase in the marketed surplus of all cereals. The model is, therefore, composed of

$$\text{CERSOLD}_i = f(\text{CERPROD}_i, \text{RICESH}_i, \ln\text{PRICE}_i, \text{DISTANCE}_i, \text{INCOME}_i, \text{INCOMESQ}_i, \text{SIZE}_i, \text{SIZESQ}_i). \quad (13)$$

(For details of variable definitions, see Table 26.)

The estimation results are given in Table 26. They suggest a significant positive elasticity of marketed surplus for supply and for price. Evaluated at sample means, a 10 percent increase in cereal production increases sales by 8.4 percent. A 1 percent increase in the (rice) price would increase sales by 2.9 percent, which appears to be a rather high price elasticity. Given the cross-sectional nature of the analysis, a cautious interpretation of this price elasticity is suggested. One certainly would like to assess

Table 26—Marketed surplus model for cereals: regression results

Explanatory Variable ^a	Parameter	t-Value	Mean of Variable
CERPROD	0.0701	5.89	2,401.63
RICESH	344.7470	5.50	0.57
lnPRICE	621.1690	1.91	-0.07
DISTANCE	-25.4168	-2.80	3.31
INCOME	0.0273	0.32	1,344.55
INCOMESQ	-1.8905E-6	-0.10	2,122,666.40
SIZE	0.3315	0.05	9.37
SIZESQ	-0.0876	-0.44	123.41
Constant	-46.208	-0.38	...
R ²	0.430		
F-value	18.55		
Degrees of freedom	200		

Notes: Dependent variable—cereals sold (kilograms of all cereals in milled equivalent per compound). The mean value of the dependent variable, CERSOLD, is 201.1 kilograms. The unit of observation is the compound or, in the case of some large compounds, the subunit (*sinkiro*—a cooking and consumption group).

^a Definitions of variables:

- CERPROD = cereals produced in wet season 1985 per compound (kilograms of all cereals in milled equivalent);
- RICESH = share of rice in total cereal production, wet season 1985;
- lnPRICE = rice price in dalasi/kilogram (logarithm of village mean price);
- DISTANCE = distance to main market from each village;
- INCOME = total expenditure (as income proxy) per adult-equivalent person for 1985/86 (in dalasi);
- INCOMESQ = income squared;
- SIZE = size of compound in adult-equivalent persons; and
- SIZESQ = size squared.

the marketed surplus-price relationships more closely with a dynamic model, which the data, however, do not permit. Marketed surplus shrinks with increased distance from the market place by 13 percent for every kilometer, other things held constant. The critical role of market infrastructure for market integration is highlighted by this estimation result. An increased share of rice production in total cereal production expands marketed surplus beyond the total cereal supply of the compounds. Compounds with a higher share of rice in their total cereal supply become more market-integrated as sellers (and buyers) of cereals: a 10 percent increase in the rice share leads to a 17 percent increase in marketed surplus. Thus the new rice project enhances market integration as the supply share of the most marketable cereal expands and total supply increases. Neither the income-related nor compound size-related variables show up significantly in the model.

Effects on Storage and Storage Control

Cereal storage in the compounds involves different institutional rules. The various subdivisions of the compound may or may not maintain different storage places in which their grain stock is kept under their control. The storage place of each stock is institutionally defined by the mode of production under which it was cultivated (communal or individual). The right to extract produce from these various stocks lies with the individuals or subgroups in charge of the specific storage space.

Most storage locations (47 percent) are found under the control of the compound head. Personal storage by other individuals is also widespread (28 percent of stores). Eight percent of the stores were defined as *sinkiro* (cooking unit) stores, 8 percent as *dabada* (working unit) stores, and 9 percent as other stores. Individually controlled stores usually hold only small quantities for sale to cover personal expenses. About two-thirds of all cereals stored are under the control of the compound heads. Despite remarkable fluctuations in volume stored by season, this share remains fairly constant (63 percent in the wet season and 65 percent in the after-harvest dry season when total storage is nearly four times the wet-season quantity). Women were in charge of only 15 percent of cereal stocks in the dry season (storage was assessed in February 1986), but they held about one-third of the stored rice.

The crop composition of cereal storage changes substantially between seasons. Rice made up about 90 percent of stocks held by the sample households during the wet season and 41 percent in the dry season. The remaining stocks were made up of coarse grains.

The pronounced seasonality of Gambian agriculture and food availability shows up clearly in per capita storage levels. During the hungry season an average of 16 kilograms was held in store, while in the dry season the average was 64 kilograms. The dry-season crop from the scheme obviously smooths out the seasonal differences. The overall figure for the wet season is, therefore, not representative for the country or comparable environments in the region.

This is more the case when considering the group with no or very little access to the rice project. The quartile of compounds with least access held only 4 kilograms of cereals per capita in the hungry season, compared with 29 kilograms in the top quartile. On the other hand, in the dry season 100 kilograms per capita were held by the bottom quartile versus 61 kilograms by the top. Compounds with little dry-season rice production attempt to bridge the hungry season with higher opening stocks of coarse grains from wet-season production.

Storage levels vary little by income in this setting. At the low and high storage points, the poor have about as much in stock as do the upper income quartiles. Table 27 shows this for the 75 compounds that have little or no access to the Jahally-Pacharr project. These numbers are, therefore, not much affected by the dry-season irrigated rice production. Equally low storage levels of 5-7 kilograms per adult-equivalent person in the wet season in the compounds across all income groups do not mean, however, that consumption levels are similarly uniform. This is discussed in Chapter 6.

It should be noted that averages cover variability in the storage figures. Many of the compounds with little access to dry-season rice fields have totally depleted their stocks by the middle of the wet season and survive on the basis of almost daily by-the-cup purchases of rice. Even brief disruptions in the ability to acquire food (rice) in that period of the year may result in acute food consumption shortfalls. The increased storage levels due to rice from the project in this critical period of the year certainly improve household-level food security. It is not only the average annual increase of output due to new production technology that matters in this setting, but also the seasonal timing and reliability of it. Respective aspects of these considerations are further evaluated in the following analysis on income effects.

Income Effects

The analysis of agricultural production effects of the new rice technology showed an increase in labor productivity. This is expected to translate into increased per capita income and consumption. The analysis in this section evaluates (1) the pattern and seasonal change in income sources and the role of increased rice income in this context, and (2) the effects of the new technology on distribution of income.

The analysis is based on a complete income accounting carried out for the two periods covered by the survey. Season 1 covers March-August 1985, and Season 2 covers September 1985-February 1986. Thus, Season 1 includes the dry-season crop income and Season 2, the wet-season crop. In both seasons, livestock income and income from off-farm work, craft work, and trading as well as income transfers (remittances) are accounted for. For this analysis the income data were collected at the individual level in the compounds and then aggregated at the compound or compound subunit level where applicable. Table 28 gives a breakdown of the income accounts by upland and lowland villages.

Table 27—Seasonal cereal storage in compounds outside the project, by income group, 1985/86

Season	Income Groups ^a			
	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
	(kilograms of stored cereals/adult-equivalent person)			
Wet ^b	4.6	4.6	5.0	7.0
Dry ^c	80.8	58.7	95.1	102.2

Source: Computed from 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Total expenditure per year per adult-equivalent person is used as an income proxy.

^b In August/September 1985.

^c After harvest (March 1986).

Table 28—Income in upland and lowland project villages and nonproject villages, by source, 1985/86

Income Source	Income per Adult Equivalent			Total Average
	Lowland Project Villages	Upland Project Villages	Villages Outside Project	
	(dalasi)			
Season 1 (March-August 1985)				
Rice	123	46	40	87
Animals	-5	-4	-7	-5
Vegetables	3	1	10	3
Total own agriculture*	120	42	43	85
Total off-farm	113	61	104	95
Total income (Season 1)	233	103	146	180
Season 2 (September 1985-February 1986)				
Rice	237	60	64	157
Millet, sorghum, maize	62	248	86	127
Groundnuts, cotton	95	300	151	171
Animals	-8	11	-3	-1
Vegetables	9	13	29	13
Total own agriculture*	389	625	322	460
Total off-farm	71	58	65	66
Total income (Season 2)	459	683	387	526
Total annual income	692	786	533	706

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

* Cost of tools is deducted here.

Average per capita income was US\$116 per year (at a parallel exchange rate). The average of the highest income quartile was only 3.7 times the average of the lowest (Table 29). However, the notion of homogeneous poor peasants would be grossly misleading. Although most of the income earned is from own agricultural production (77.5 percent), income from other sources is not negligible. Average nonagricultural income stands at 22.8 percent, but it is 25.8 percent in the top quartile versus 20.4 percent in the bottom. In Season 1 (March-August), nonagricultural income is more important than agricultural earnings, particularly among the poorest. Income from animal production was on average negligible at the study site in 1985/86. This may be due to low prices in the drought year 1984/85, animal losses, and low sales volume in 1985/86.

In the lowest income quartile, the seasonality of the income flow is most pronounced: 80 percent of income is earned in the second season, while it is 72 and 75 percent in the two upper quartiles. Season 1 and Season 2 income is significantly correlated. In other words, the poor are poor in both seasons. Consequently, annual income correlates significantly with hungry-season income with a correlation coefficient of 0.48.

Rice production (including rice for own consumption) is a major income source in the sample compounds. An average of 34 percent of total annual income derives from rice, yet the importance of rice for income varies widely. In compounds from villages outside the project, rice production generates only 20 percent of total income (Table 28). This situation may be comparable to the preproject situation, since the two study villages outside the project are lowland communities with swamp rice and some old-scheme rice production. In the lowland villages of the project, rice (from all sources) now contributes 52 percent of income, while it is 13 percent in the upland villages

Table 29—Main income sources, by level of per capita income, 1985/86

Income Source	Per Capita Income Groups				Total Average
	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	
(percent of annual income)					
Season 1 (March-August 1985)					
Own agriculture	7.3	12.5	15.6	10.7	12.1
Off-farm work and transfers	12.8	12.7	12.5	14.6	13.5
Total	20.2	25.2	28.2	25.3	25.6
Season 2 (September 1985-February 1986)					
Own agriculture	72.2	66.4	64.0	63.4	65.4
Off-farm work and transfers	7.6	8.3	7.8	11.2	9.3
Total	79.8	74.8	71.8	74.7	74.8
Total annual	100.0	100.0	100.0	100.0	100.0
Total annual income per adult equivalent (dalasi)	327	568	767	1,147	703
Total annual income per adult equivalent (US\$)*	65	112	152	227	139
Total annual income per person (US\$)*	64	93	127	189	116
(Number of observations)	(55)	(56)	(56)	(57)	(224)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

* Converted at parallel exchange rate (US\$1.00 = 5.06 dalasi).

(new tillers). In the top quartile of compounds with the most access to new rice fields, rice provides 67 percent of annual income. This is also the group with the least seasonal fluctuation of income due to the fully water-controlled technology, which ensures an income source in the hungry season.

Rice production has relatively greater importance for the poorest farmers (43 percent of income) than it has for the top income quartile (26 percent). The new rice technology has contributed—at least in the short run—to a more equal distribution of income in the area. The households that would benefit most from further improvement in labor and land productivity of rice are those currently earning a high share of their income in rice, and this is relatively more the case for the poorer households. This also means that any deterioration in yields in the project would most adversely affect poorer households.

Determinants of Income Differences

The causes of income differences in rural West Africa do not lend themselves to easy conceptualization. Socioanthropological determinants, such as status, lineage, and ethnicity, which determine access to and control over resources, play a major role and interact with more general economic factors, such as acquired human capital and the capital stock for agricultural production (tools, livestock) (Hill 1970, Meillassoux 1981). An attempt is made below to identify the factors that determine income differences in this area through an income-earning model and to assess the incremental role of access to new rice technology in this context (see also conceptual framework, Chapter 2, equation [6]).

The following hypotheses underlie the multivariate analysis. The main factor of production in all income-earning activities in the area is labor. The size and demographic composition of a compound (size of work force, share of women and children, age of

compound head) is crucial for its income earning. Endowment with human capital is difficult to assess in this environment, where almost invariably a few years of Koranic school training is obtained by the heads of the households. Yet, acquired skills in craft work are of importance and are included in the model. Where production is concerned, agricultural income—the main income source—is hypothesized to be determined (beyond labor) by agricultural capital (that is, labor-saving equipment and the size of livestock herds). Access to project land can be interpreted as a capital asset, too. It is included to test for its effects besides the other factors mentioned. The model also tests whether a higher share of communal agriculture (*maruo*) reduces efficiency—a compound labor force might be more concerned with its private fields—and thereby the per capita income of compounds. Finally, the effect of ethnic differences (that is, Serahuli who are more involved in craft work and trading) was tested, and whether compounds residing longer in the area do better. The model is thus specified as follows:

$$\text{INCOME}_i = f(\text{HHDEMO}_i, \text{QUALJOB}_i, \text{AGCAPITAL}_i, \text{MARUOSH}_i, \text{FOUNDED}_i, \text{SERAHULI}_i, \text{LOCATION}_i), \quad (14)$$

where

- INCOME_i = income per capita (adult equivalent) in dalasi per year (1985/86);
 HHDEMO_i = compound size and demographics (see variables WORKPERP, CHLDAE, WOMENSH, AGECH in Table 30 notes);
 QUALJOB_i = human capital-related variable (qualification as craftsman);
 AGCAPITAL_i = agricultural capital-related variables (see AGTOOL, ANIMUNIT, NEWRICE in Table 30 notes);
 MARUOSH_i = share of land under communal crops in total crop land;
 FOUNDED_i = if compound was founded long ago (>10 years) = 1, else = 0;
 SERAHULI_i = if compound is Serahuli = 1, else = 0; and
 LOCATION_i = if compound is in lowland village = 1, else = 0.

The estimation results of this income-earnings analysis are presented in Table 30. From the model results, four points should be highlighted:

1. On the average, an additional plot of new rice land allotted to a compound significantly increases per capita income by D92 per adult-equivalent person per year. This is equivalent to 13 percent at the sample mean.²⁶ That this is a fairly stable and reliable income increase is noteworthy. This result for the net income effect appears to be consistent with the earlier findings of major substitution effects (labor) between crops in compounds with access to new rice land (Chapter 4).

²⁶ One plot equals 0.5 hectare divided by 9.2 adult-equivalent persons (per compound or compound subunit) multiplied by the parameter value of NEWRICE (1,688.5), which is on a per hectare basis.

Table 30—Determinants of income differences and the role of new rice technology for income

Variable ^a	Parameter	t-Value	Mean of Variable
WORKPERP	6.913	1.15	5.78
CHLDAE	-333.641	-3.77	0.57
WOMENSH	-81.822	-0.67	0.51
AGECH	-69.591	-2.37	6.12
QUALJOB	290.364	2.83	0.14
AGTOOL	232.336	3.61	0.29
MARUOSH	48.242	0.54	0.59
ANIMUNIT	44.986	3.62	1.29
NEWRICE	1,688.496	3.39	0.06
FOUNDED	57.857	1.25	0.69
SERAHULI	249.633	2.43	0.05
LOCATION	13.362	0.22	0.44
Constant	973.386	4.84	...
R ²	0.256		
F-value	5.75		
Degrees of freedom	200		

Notes: Dependent variable—annual income per adult equivalent. Mean value of dependent variable, INCOME, is 705.03 dalasi. Unit of observation is the compound or, in the case of some large compounds, the subunit (*sinkiro*—a cooking and consumption group).

^a Definitions of variables:

- WORKPERP = persons in working age present in compound;
- CHLDAE = ratio of number of children under 4 years of age over adult-equivalent persons;
- WOMENSH = share of women in WORKPERP;
- AGECH = age of compound head (age groups 4 . . . 7);
- QUALJOB = ratio of number of persons with special skills over WORKPERP (for example, craftsmen, healers);
- AGTOOL = dummy = 1, if access to multipurpose tool for weeding and other purposes;
- MARUOSH = share of communal land in total land use of compound;
- ANIMUNIT = number of animals per adult person (animals converted to cattle equivalents on value basis);
- NEWRICE = amount of land in the rice project in hectares per adult equivalent (land in fully water-controlled equivalents);
- FOUNDED = dummy = 1, if compound was founded more than 10 years ago;
- SERAHULI = dummy = 1, if ethnic group is Serahuli; and
- LOCATION = dummy = 1, if lowland village.

2. An increased share of persons with specific skills for nonagricultural income-earning significantly increases per capita income (QUALJOB).

3. Accessibility of labor-saving tools (AGTOOL) increases per capita income, all else remaining the same, by 34 percent; the livestock effect for income is significant but not very large in terms of proportion to income (D45 per cattle unit); and increased share of communal agriculture does not appear to reduce per capita income (MARUOSH).

4. Over and above the discussed determinants of income, compounds in upland villages do not have significantly different income levels from those in lowland villages, but it is found that the Serahulis are significantly richer than the rest of the sample's ethnic groups.

Effects at Intrahousehold Level

In view of the very heterogeneous economic situation within the compounds, the distributional effects of the new technology should be considered not only at the aggregate household level, but also at the intrahousehold level. Considerable attention has been focused on the issue of intrahousehold resource distribution in recent years, following a growing recognition that neither poverty nor development interventions affect all members of the household uniformly (Lele 1986, Folbre 1986, Haaga and Mason 1987). There is a practical concern that project and policy initiatives that raise overall household incomes may at the same time be the cause of shifts in patterns of intrahousehold resource allocation that result in a negative effect on certain individuals. This concern relates primarily to the differential effect of changes on women versus men, and on different age groups within the household (Due 1987).

As was described earlier, compounds are stratified internally by various age/sex/status hierarchies, and may also be divided into subunits that operate on a semiautonomous basis. The benefits and burdens of technological change and commercialization can, therefore, be spread very differently among these various groups.

For example, it has already been emphasized that the introduction of the new rice production technology led to a transformation of the status of the crop: traditionally a women's crop grown to a large extent on private farms, it became mainly a communal crop under the authority of the male compound head. Yet this transformation in the status of rice involved more complex changes in the system at the intrahousehold level than a simple switch from a woman's to a man's crop. The reassignment of rice as a communal crop has (1) led to an increase in the burden of communal agricultural work for both men and women, but relatively more for women; (2) reduced the opportunity for women to grow rice as a private cash crop; and (3) resulted in an increasing centralization of authority in the compound head, manifested primarily in his newfound control over the rice crop (von Braun and Webb 1989).

The designation of project rice as a full-fledged communal crop has meant that the labor demands of communal farming as a whole have increased substantially in absolute terms. The burden of communal labor has therefore increased for both men and women, relative to the burden of private agriculture. Yet in this shift, the women's share of work in communal agriculture has risen relatively more than the men's. At the same time, the swamp fields, which women formerly cultivated with traditional rice (largely as a mixed private and communal crop) were much reduced in favor of the new rice plots. Both of these changes have led to a reduced ability of individual farmers (especially women, but also some junior male compound members) to maximize individual profit as private farmers and to a resultant centralization of power in the hands of senior male compound members.

This is not to imply, however, that women are necessarily dispossessed of all individual farming rights or of an independent income. It was shown in Chapter 4 that women organize private production of upland cash crops, such as groundnuts and cotton. In addition to this upland income, many women are also paid by the compound head for work that they carry out in the new project rice fields. Table 31 shows that payments ranging from 0.08 to 2.58 kilograms of rice have been given to women for each day of work that they spend in the communal project fields. The variability of payments by village is dictated by the extent to which those villages were formerly involved in swamp rice production and by the amount of swamp rice land still available for cultivation to the women in the various communities. (For example, of the eight project villages, Pacharr has the largest amount of swampland still available to its women and therefore shows one of the smallest payments.)

Table 31—Intrahousehold payment to women for work in project communal rice fields, wet season 1985

Village	Rice Given to Women by Compound Head for Work in Communal Fields	Number of Observations
	(kilograms/day of work)	
Traditional rice growers		
Dasilameh	1.95	62
Pacharr	0.08	104
Sinchou Abdou	1.30	15
Sukurr	2.58	27
New rice growers		
Njoben	a	...
Sare Samba Sumali	0.24	16
Kussalang	a	...
Sare Bala	a	...
Total mean	1.23	224
(US\$/day)	(0.35)	

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

a Women from these villages work very little in *maruo* (communal) rice (fewer than 10 cases observed in all three villages).

A payment of 2 kilograms per day is equivalent to a daily wage rate of around D2. This is the same amount as a woman's net returns from cultivating a private field of cotton, which was the least productive of the women's crops, but less than the average returns gained by women from swamp rice (Table 17). The highest in-kind payments to women were recorded in Sukurr and Dasilameh (traditional rice-tilling villages), with much lower rates of payment in the Fula villages and in Njoben (a Wolof village).

Combined with these readjustments in divisions of labor by sex and crop, and the altered sources of private farm income for women, there has been an overall centralization of control over the rice crop by the compound head and an associated increase in his authority. For example, the following responsibilities related to rice were mostly in the hands of women when growing swamp rice before the introduction of the new rice technology and are now mainly the purview of the compound head: demarcating plots (between communal and private portions), controlling activities in the fields, assessing how much rice to sell or store, deciding in whose store to keep the rice, and determining the quantity of rice to be used for cooking each day. Because the new rice is a communal crop, women automatically have a reduced say in its production and disposal.

Inevitably, not all women and men have benefited from the increased male involvement in rice production. In compounds with relatively few upland fields that can be taken over by women, or in those where compound heads do not pay women for their work in the new rice fields, women have suffered an absolute increase in work and a decline in independent income. In other compounds women are faring much better than in former days. A great variety of gainer-loser patterns is apparent. To assess these patterns completely from the income side by looking at time allocation is difficult. Fungibility between male and female income and time, for instance, is difficult to capture. The following consumption and nutrition analysis sheds additional light on the welfare effects for the various compound members and addresses the intrahousehold issues from a different angle.

FOOD AND NONFOOD CONSUMPTION EFFECTS

The findings reported in the previous sections showed that technological change in rice greatly increased rice production and added substantially to household food production. Because of substitution effects, net income effects were less sizable. This chapter addresses the extent to which these increases translate into spending on food and nonfood items, availability of food from own production for consumption, and actual consumption of food (in the form of calories). Particular attention is focused on the seasonal effects on food consumption because the study site is well known for its wet-season deficiencies in food availability, which coincide with the highest energy expenditures during this period of heaviest agricultural workload. The dry-season, pump-irrigated rice was found to reduce fluctuations in seasonal cereal availability.

Spending on Food and Nonfood

What do rural households in The Gambia spend their income on, especially their incremental income, and what role does increased income deriving from new rice technology and commercialization play in this context?

The following expenditure information is aggregated on the basis of *sinkiro*-level food consumption (the common pots) and expenditure information from person-by-person recall surveys in each season. In the case of the individual data, about 800 adults were interviewed concerning the previous week's expenditure on food snacks by themselves and their children and on both short-term and long-term nonfood expenditures.

Fifty-six percent of all expenditures (including the value of own-produced food) is devoted to communal food consumption in the *sinkiro*, 10 percent is spent on snack foods, 17 percent on frequently purchased nonfood items (such as soap and tobacco), and 17 percent on (semi-) durables, such as housing, clothes, and household goods. There is considerable stability in the budget shares for these aggregates over the two seasons. Savings, borrowings, and the seasonal depletion and rebuilding of capital stocks all serve to level out the seasonality of agricultural income flows.

There are significant changes in expenditure levels on certain individual items. For example, health expenses are higher during the disease-prone wet season than during the dry season. Housing expenses are concentrated in the late dry-season months when less field work permits more time to be spent on construction work (the wet season 1985 recall period covers the prerains period of 1985). Clothes are typically purchased after money from the groundnut harvest comes in early in the dry season.

Total expenditures substantially exceed recorded total income but the two are reasonably correlated ($r = 0.64$). While part of the difference is probably due to the common underreporting of income, the particularly large difference in the wet (hungry) season of 1985 is mostly the result of household selling of assets for current expenditures in that season, which was particularly difficult after several years of low rainfall.

The share of food expenditures fluctuates more in upland villages between seasons than it does in lowland villages, because the latter have access to more pump-irrigated rice (a second crop) with its leveling effects on seasonality (Table 32). The larger fluctuation in the food budget of upland villages is paralleled by larger absolute seasonal fluctuations in their nonfood budgets.

Table 32—Budget shares of own-produced and purchased food and nonfood items in upland and lowland village sinkiros, by season, 1985/86

Item	Lowland Villages		Upland Villages	
	Wet Season	Dry Season	Wet Season	Dry Season
Common food				
Dalasi/adult-equivalent person	292	442	312	488
Percent of total expenditures	52.9	54.8	61.4	55.1
	(percent of common food)			
Rice	49.3	43.8	38.1	19.4
Millet, sorghum	1.3	12.9	13.5	34.5
Maize	0.6	0.7	3.5	2.8
Groundnuts	4.2	6.7	10.2	18.0
Sauce ingredients	10.1	10.3	6.5	8.4
Vegetables	7.9	4.8	9.4	3.2
Oil	4.8	4.0	2.9	2.2
Fish	6.0	5.7	3.2	4.3
Meat	4.9	4.5	5.0	4.4
Milk	4.0	1.1	4.2	0.5
Sugar	5.2	4.7	3.1	1.9
Other	2.0	0.9	0.4	0.5
Snack food				
Dalasi/adult-equivalent person	50	85	39	96
Percent of total expenditures	9.0	11.2	6.8	11.2
	(percent of snacks)			
Groundnuts (as snacks)	6.5	13.8	4.8	16.3
Bread	33.8	18.6	38.3	21.2
Beverages	14.4	31.5	12.7	27.9
Fruits	21.9	19.8	7.2	13.8
Sugar	19.8	13.3	32.7	20.2
Other	3.6	3.0	2.9	0.7
Frequently purchased nonfood				
Dalasi/adult-equivalent person	109	135	91	136
Percent of total expenditures	20.0	17.4	16.3	16.0
	(percent of frequently purchased nonfood)			
Washing soap	27.6	32.0	29.8	32.0
Energy	17.6	16.9	16.9	16.2
Batteries	10.0	9.3	14.1	17.3
Tobacco, cola nuts	36.9	29.6	34.1	30.9
Transport (short distance)	6.0	8.5	3.9	3.4
Semidurables				
Dalasi/adult-equivalent person	104	131	85	159
Percent of total expenditures	18.2	16.7	15.5	17.7
	(percent of semidurables)			
Housing	4.4	2.7	5.2	2.5
Household goods	19.3	18.4	17.5	15.9
Clothes	31.1	38.6	30.0	39.8
Luxuries	7.7	9.3	10.1	7.9
Health	6.6	4.9	5.9	2.8
Education	2.0	2.4	0.7	0.1
Travel (long distance)	4.1	3.9	4.2	2.7
Festivities	4.8	5.3	6.8	4.8
Bride price	4.0	2.6	3.8	5.6
Miscellaneous	9.4	5.5	7.2	9.2
Taxes	5.8	6.6	8.6	8.7
Total expenditures (dalasi/adult-equivalent person)	555	793	527	879

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: A *sinkiro* is a cooking and consumption group within a compound. Parts may not add to totals because figures represent the means of share means.

The nonagricultural rural economy benefits from increased income earned from rice production and spent on locally produced goods and services. Table 33 gives a breakdown of average expenditures for the lowest and highest expenditure quartiles. On the basis of this information, it can be calculated that an increase in total expenditure of 10 percent causes expenditures on (semi-) durables to rise by 14.5 percent and expenditures on housing and household goods to rise by 24 percent. Changes in nonfood expenditures, however, start from a very low base. Thus, despite substantial relative changes, the multiplier effects of this increased spending for nonagricultural employment may remain small for the time being. Nevertheless, the potential for nonagricultural growth stimulated through the agricultural growth at the study site is substantial. An increasing diversification of the local economy is observed in the central market village of Brikama Ba (next to Dasilameh), where tailors, goldsmiths and silver-smiths, furniture and pot makers, weavers, and car mechanics have converged in the past few years to profit by the increased rice trade.

The tendency to spend incremental income on food is high in this area. This is looked into with a simple regression model, explaining food expenditure levels. The model is formulated with the following hypotheses in mind: a *sinkiro*-size variable (HHSIZE) supposedly controls for scale effects. The variable "income earned from cultivation in new rice project over total income earned in both seasons by *sinkiro* (PROJINC)" tests for effects of new technology in rice production on spending for food beyond its income effect, which is controlled for with the total expenditure variable as an income proxy (lnTOTEX). It is expected that the propensity to spend on food decreases with rising income (lnTOTEXSQ). It should be noted that the value of own-produced food consumed by the *sinkiro* (priced at respective purchase prices) is included in the food expenditures.

$$\text{FOODEX}_i = f(\text{HHSIZE}_i, \text{lnTOTEX}_i, \text{lnTOTEXSQ}_i, \text{PROJINC}_i), \quad (15)$$

where

FOODEX_i = expenditure on food (including value of own produced) per adult-equivalent person in wet and dry seasons in *sinkiro* (i),

HHSIZE_i = number of adult-equivalent persons in *sinkiro*,

lnTOTEX_i = total expenditure (log) in both seasons in *sinkiro* per adult-equivalent person,

lnTOTEXSQ_i = lnTOTEX_i squared, and

PROJINC_i = income earned from cultivation in new rice project over total income earned in both seasons by *sinkiro*.

The estimation results are presented in Table 34.

It is found that an increase in income from the project does not significantly alter spending behavior toward food beyond its income effect. The parameter value for the variable PROJINC is statistically insignificant. Larger *sinkiros* spend less per capita for any additional member. This may be so because acquisition and preparation of food in bulk in the larger *sinkiros* permits savings.

Applying the parameters to sample mean values suggests that a 10 percent increase in total expenditure leads to a 9 percent increase in food expenditure or, in other words, of an incremental D1.00, D0.60 is spent on food.

Table 33—Budget shares of own-produced and purchased food and nonfood items in sinkiros, by expenditure quartile and season, 1985/86

Item	Lowest Expenditure Quartile		Highest Expenditure Quartile	
	Wet Season	Dry Season	Wet Season	Dry Season
Common food				
Dalasi/adult-equivalent person	196	313	432	711
Percent of total expenditures	59.2	58.8	53.5	54.9
	(percent of common food)			
Rice	48.8	33.2	36.3	35.1
Millet, sorghum	7.7	26.8	9.2	15.2
Maize	1.9	1.4	1.0	1.8
Groundnuts	5.6	12.0	7.1	10.3
Sauce ingredients	8.2	8.0	9.4	9.9
Vegetables	9.2	3.9	8.0	4.8
Oil	2.3	1.7	5.0	4.4
Fish	4.5	5.2	5.5	5.7
Meat	3.6	3.4	7.3	5.8
Milk	2.6	0.9	4.9	1.1
Sugar	4.5	3.2	4.4	4.8
Other	1.2	0.4	2.0	1.3
Snack food				
Dalasi/adult-equivalent person	27	49	72	133
Percent of total expenditures	8.1	9.7	8.7	11.3
	(percent of snacks)			
Groundnuts (as snacks)	5.6	15.9	6.5	13.3
Bread	37.1	22.3	35.6	20.4
Beverages	12.2	25.9	17.6	30.2
Fruits	15.1	20.5	14.1	15.8
Sugar	24.7	13.2	23.6	17.2
Other	3.3	2.1	2.6	3.0
Frequently purchased nonfood				
Dalasi/adult-equivalent person	60	82	143	200
Percent of total expenditures	17.8	15.9	17.7	15.9
	(percent of frequently purchased nonfood)			
Washing soap	27.7	33.5	32.1	29.3
Energy	16.8	16.6	17.6	16.2
Batteries	11.6	10.3	11.8	13.9
Tobacco, cola nuts	40.0	32.7	33.6	31.3
Transport (short distance)	3.6	4.4	3.7	6.0
Semidurables				
Dalasi/adult-equivalent person	49	79	166	230
Percent of total expenditures	14.9	15.5	20.1	17.0
	(percent of semidurables)			
Housing	4.0	1.7	6.8	2.5
Household goods	16.4	18.7	20.0	17.2
Clothes	32.2	42.6	28.9	33.5
Luxuries	7.3	6.5	10.3	12.0
Health	6.5	3.8	5.9	5.0
Education	2.2	1.7	1.3	1.2
Travel (long distance)	3.0	2.8	5.0	3.4
Festivities	6.1	3.6	5.4	4.5
Bride price	2.8	1.3	4.1	5.9
Miscellaneous	8.0	7.3	7.6	7.0
Taxes	9.7	10.2	4.6	7.2
Total expenditures (dalasi/adult-equivalent person)	331	523	813	1,273

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: A *sinkiro* is a cooking and consumption group within a compound. Parts may not equal totals because figures represent the means of share means.

Table 34—Spending on food: regression model

Explanatory Variable	Parameter	t-Value
HHSIZE	-12.64	-6.11
PROJINC	-53.33	-1.19
lnTOTEX	-8,096.71	-9.83
(lnTOTEXSQ)	615.28	11.00
Constant	27,378.81	9.03
R ²	0.835	
F-value	255.9	
Degrees of freedom	202	

Notes: Dependent variable—expenditure on food in *sinkiro* during wet and dry seasons per adult-equivalent person. A *sinkiro* is a cooking and consumption group within a compound.

The high level of food expenditure elasticities confirms findings from other African surveys reported by Alderman (1986, 38): low-income rural households in two regions of Nigeria show elasticities of 0.89-1.04, and in Sudan, 0.84.

As reported in the next section, calorie consumption increases with rising income, but decreasingly so at the margin opposite to the total food expenditures. Thus it is less a quantity effect than a quality effect in foods consumed that pushes food expenditures relatively upwards. As shown in Table 33, the budget shares of expensive food items such as oils, fish, meat, milk, and snack foods increase disproportionately with higher total expenditures, and more so than the relative reduction in spending on basic foods.

Clearly, demand for food remains high across all income groups. The absolute value of per capita cereal consumption in the top expenditure quartile is 75 percent higher than in the bottom quartile. It can be safely assumed that any income-generating activity in this area will stimulate a rapid expansion in food demand. This has implications for the rapid expansion of food production in rice projects such as the Jahally-Pacharr. It should not come as a surprise that increased food production, adding to income and thus to demand for food (including staples), does not add much to marketed surplus at current consumption levels. Effects of increased income for consumption and nutrition should be expected to be significant under these circumstances.

Calorie Consumption and Sources of Food Energy

In 1978-81, FAO food balance sheets calculated the average daily per capita supply of energy in The Gambia to be 2,251 calories and of protein to be 57 grams (FAO 1985b). (The energy estimate was 4.1 percent less than that made a decade earlier.) Food balance sheets, which provide an estimate of food available for The Gambia as a whole, are based on production, trade, and stock figures, which may not be easy to calculate precisely. Moreover, they do not provide information on geographical, socioeconomic, or seasonal variations in food availability, which may be of considerable nutritional importance. Such information is obtained from household (or individual) food consumption surveys, of which there have been comparatively few in The Gambia.

In 1946, in a small but classic study, Doughty (1950) examined food consumption in five *sinkiros* in Yoro Beri Kunda, a village in our survey area. The annual average figures reported for individual compounds range between 2,365 and 1,556 calories per capita per day in this small but carefully conducted survey. Monthly figures range between 1,240 in the hungry season and 2,780 in the postharvest season.

In 1978/79, in a survey in Lower River Division (about 100 kilometers west of our survey area), Phillips, Coles, and Seaman (1982) studied two lowland villages and

found that, on average, seasonal variations in energy consumption were comparatively small. For one village, average per capita calorie intakes were 1,920 in the dry season (March), 1,848 in the wet season (July-September), and 2,147 postharvest (December). For the other village, the figures were 2,110, 2,186, and 2,262 calories, respectively. However, substantial differences were identified in calorie consumption between households. In the dry season, per capita calorie intakes ranged from 1,445 to 2,499 in the 20 main sample households. In the rainy season, the variation between households was from 1,355 to 2,811 calories (Phillips, Coles, and Seaman 1982, 104-105). The surveys of Doughty (1950) and Phillips, Coles, and Seaman (1982) were based on several consecutive records for each time period. The weighed method was used for household food consumption, with individual recall for snacks. Phillips, Coles, and Seaman found that protein intake was above recommended requirement levels throughout the year, mainly because of high groundnut consumption. Since the area of the present study is probably similar in that respect, the following analysis concentrates on calorie consumption and not on protein.

Survey Technique

The reported calorie consumption data below are based on *sinkiro*-level information collected for one week in the rainy season (August-September 1985) and one week in the dry season (February-March 1986). All locally available foods, whether produced by the household or acquired otherwise, are included. Considerable care was taken to also collect information at the individual level on consumption of snack foods, especially the energy-dense ones, such as sweet bread, roasted groundnuts, and sugar. Mothers responded for their children on snack consumption. The *sinkiro*-level information was obtained from the head cooks who were preparing food during the week in question. The recall of food prepared by type and quantity (in local volume measures) worked backwards meal-by-meal and day-by-day.

The number of persons present at meals fluctuates to some extent. Compound members may eat with other *sinkiros*, or omit a meal when shopping at the market, and so on. An effort was therefore made to establish the precise number of persons (adults and children) present at each meal, including visitors.

Certain comments may be made about the methodology. First, in this society, head cooks have little difficulty recalling food prepared, since this is their special function in the *sinkiro*'s daily activities. In more complex situations involving several cooks, several interviews were done for the recall period for the respective days of the week.

Second, the range of foodstuffs available (and particularly those used in quantities to properly affect calorie consumption) was rather small. The measurement made was of food as prepared and served in the *sinkiro*. Since communal dishes were used, individual food consumption could not be obtained. No deduction was made for leftovers, some of which may have been wasted rather than subsequently consumed. Although Phillips, Coles, and Seaman (1982) found this wastage to be very small overall, failure to take account of it will tend to result in slight overestimation of calories consumed (particularly, perhaps in the richest households).

Chronic and Seasonal Hunger

Average per capita calorie consumption in the *sinkiros* was 2,159 in the wet season and 2,269 in the dry season. To this is to be added the consumption of snack foods consumed between meals. These snacks add up to another 221 calories (9.3 percent of total calorie consumption) in the wet season and 253 calories (10 percent) in the dry season.

Table 35 presents the calorie consumption data by expenditure quartiles. This clearly shows the strong positive relationship between income—using total expenditure as a proxy—and calorie consumption. As expected, the relationship is much stronger in the food-scarce wet season than in the dry season (after harvest). Calorie consumption increases by 54 percent from the lowest to the highest quartile in the wet season, but by only 37 percent in the dry season. While in the top quartile, calorie consumption is almost stable over the seasons (+2 percent from wet to dry season), it increased by 15 percent in the bottom quartile. Thus, food consumption by the poor reflects seasonal food scarcity, while the richer *sinkiros* are able to maintain a more constant food intake at a higher level.

Of particular concern are levels and changes of food poverty, that is, deficiencies in food calories in relation to needs. A strong inverse relationship is found between income level and prevalence of calorie deficiency (Table 36). For this particular computation, a requirement level of 2,700 calories per adult-equivalent person was chosen.²⁷ The prevalence of deficiency is presented for *sinkiros* that fall below 80 percent and below 60 percent of that level. In the hungry season, 18.4 percent are found below 80 percent and 4.2 percent are below 60 percent. By far the largest share of these *sinkiros* are in the lowest income group. Of the other *sinkiro* groups, in both seasons, only a negligible share falls below the 60 percent threshold, some of which may be "reporting noise" in the data. In the study by Phillips, Coles, and Seaman (1982), 30 percent of the 20 sample *sinkiros* had intakes below 80 percent of requirements in the wet season, compared with 10 percent in the dry season (although none were below 60 percent). The relatively higher proportion of *sinkiros* with intakes below 80 percent of requirements (as calculated according to FAO/WHO recommendations) may reflect a situation common for areas without pump-irrigated rice.

A comparable breakdown is given for *sinkiros* with different levels of access to rice fields in the project (Table 37). While deficiencies appear highest in the *sinkiros* that do not participate in the project at all, the picture remains mixed for the others. In the wet season, when project participants are benefiting from the harvest of the pump-

Table 35—Calorie consumption per capita, by income quartile, wet season 1985 and dry season 1986

Income Quartile ^a	Wet Season 1985			Dry Season 1986		
	Sinkiro Food ^b	Snacks	Total	Sinkiro Food ^b	Snacks	Total
(calories/capita/day)						
Lowest	1,724	169	1,893	2,006	170	2,176
Second	2,009	213	2,222	1,981	245	2,226
Third	2,402	220	2,622	2,526	285	2,811
Highest	2,616	301	2,917	2,648	324	2,972
Total average	2,159	221	2,380	2,269	253	2,522

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Expenditure is used as a proxy for income.

^b A *sinkiro* is a cooking and consumption group within a compound.

²⁷ Any calculation of energy requirement involves an element of judgment. Consideration has been given to recent work on women's energy expenditures and the energy cost of pregnancy and lactation by the Medical Research Center (MRC) unit in The Gambia (see Lawrence et al. 1989).

Table 36—Prevalence of calorie consumption below recommended requirement levels, by income quartile and season, 1985/86

Income Quartile ^a	Below 80 Percent of Requirements		Below 60 Percent of Requirements	
	Wet Season	Dry Season	Wet Season	Dry Season
	(percent of <i>sinkiros</i>) ^b			
Lowest	49.1	21.2	15.1	3.9
Second	17.3	18.5	0.0	5.6
Third	5.6	5.7	0.0	1.9
Highest	1.9	0.2	0.0	0.0
Total average	18.4	13.7	4.2	3.3

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Expenditure is used as a proxy for income.

^b A *sinkiro* is a cooking and consumption group within a compound.

irrigated dry season crop, increased access to project land is equated with reduced prevalence of calorie consumption deficiencies except in the lowest quartile (which includes a large share of high-income upland farm units). In the dry season, however, the picture is reversed. A considerable portion of those *sinkiros* farming large areas of project land do not consume sufficient calories (17 percent in the top quartile). This must be assessed more rigorously in a multivariate analysis that controls for other factors. Thus this simple tabulation must not be interpreted in a cause-effect perspective. Nevertheless, there are participants who experience calorie-intake deficiencies despite substantial access to the project. These are poor rice farmers with few other income sources.

The most important calorie source in the area is rice. Over both seasons, an average of 55 percent of calories comes from rice, compared with 65 percent in the wet season and 46 percent in the dry season (Tables 38, 39, and 40). While annual averages of that share show little change across income groups, poorer *sinkiros* tend to consume

Table 37—Prevalence of calorie consumption below recommended requirement levels, by access to project rice fields and season, 1985/86

Access to Rice Fields ^a	Below 80 Percent of Requirements		Below 60 Percent of Requirements	
	Wet Season	Dry Season	Wet Season	Dry Season
	(percent of <i>sinkiros</i>) ^b			
No land in project	20.7	27.6	6.9	13.8
Lowest quartile	17.0	8.7	6.4	0.0
Second quartile	22.2	8.9	0.0	0.0
Third quartile	17.8	11.4	6.7	2.3
Highest quartile	15.2	17.0	2.2	4.3
Total average	18.4	13.7	4.2	3.3

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Project land in pump-irrigated equivalent per adult.

^b A *sinkiro* is a cooking and consumption group within a compound.

Table 38—Sources of calories consumed in sinkiros, by expenditure quartile, wet and dry seasons, 1985/86

Source of Calories	Per Capita Expenditure Quartile of Sinkiros ^a				Total Average
	Lowest	Second	Third	Highest	
	(percent of total calories consumed) ^b				
Rice	53.0	60.2	52.1	54.2	54.8
Millet, sorghum	22.4	13.8	16.4	13.7	16.6
Maize	2.1	1.4	2.8	1.8	2.0
Total cereals	77.5	75.4	71.3	69.7	73.4
Groundnuts	10.7	8.9	11.9	10.8	10.6
Sauce ingredients	0.8	0.8	0.8	0.9	0.8
Vegetables	0.9	0.9	0.8	0.9	0.9
Oil	1.6	2.7	4.0	4.6	3.2
Fish	2.5	2.9	2.5	3.1	2.8
Meat	1.3	1.9	2.2	2.8	2.1
Milk	1.2	1.8	1.6	1.6	1.5
Sugar	3.3	4.5	4.4	5.0	4.3
Other	0.2	0.2	0.5	0.7	0.4
(Average calories/day/adult-equivalent person)	(2,117)	(2,355)	(2,846)	(2,952)	(2,570)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a A *sinkiro* is a cooking and consumption group within a compound.

^b Annual averages for wet and dry seasons, 1985/86.

Table 39—Sources of calories consumed in sinkiros, by expenditure quartile, wet season 1985

Source of Calories	Per Capita Expenditure Quartile of Sinkiros ^a				Total Average
	Lowest	Second	Third	Highest	
	(percent of total calories consumed)				
Rice	68.6	70.1	63.2	59.1	65.2
Millet, sorghum	8.7	3.7	6.1	8.5	6.8
Maize	2.4	0.8	3.5	1.3	2.1
Total cereals	79.7	74.6	72.8	68.9	74.1
Groundnuts	6.4	6.8	7.8	8.7	7.4
Sauce ingredients	1.0	0.8	0.8	1.1	0.9
Vegetables	1.5	1.2	1.1	1.0	1.2
Oil	1.6	3.2	4.2	4.9	3.5
Fish	2.4	3.1	2.6	3.1	2.8
Meat	0.9	2.2	2.4	3.2	2.2
Milk	2.0	2.6	2.6	2.5	2.4
Sugar	4.4	5.5	5.2	5.8	5.2
Other	0.1	0.1	0.7	0.9	0.5
(Average calories/day/adult-equivalent person)	(1,973)	(2,324)	(2,741)	(2,860)	(2,477)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a A *sinkiro* is a cooking and consumption group within a compound.

Table 40—Sources of calories consumed in sinkiros, by expenditure quartile, dry season 1986

Source of Calories	Per Capita Expenditure Quartile of Sinkiros ^a				Total Average
	Lowest	Second	Third	Highest	
	(percent of total calories consumed)				
Rice	40.3	52.2	42.3	49.7	46.2
Millet, sorghum	33.0	22.9	26.5	18.7	25.2
Maize	1.9	1.9	1.8	2.6	2.1
Total cereals	75.2	77.0	70.6	71.0	73.5
Groundnuts	14.3	10.6	15.2	12.7	13.2
Sauce ingredients	0.8	0.8	0.8	0.8	0.8
Vegetables	0.6	0.7	0.7	0.7	0.7
Oil	1.7	2.3	3.6	3.8	2.9
Fish	2.6	2.8	2.5	3.1	2.8
Meat	1.6	1.3	1.9	2.3	1.8
Milk	0.6	0.7	0.7	0.7	0.7
Sugar	2.6	3.6	3.6	4.3	3.5
Other	0.2	0.2	0.3	0.5	0.3
(Average calories/ day/adult-equivalent person)	(2,261)	(2,387)	(2,952)	(3,045)	(2,663)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a A *sinkiro* is a cooking and consumption group within a compound.

a higher share of their calories in the form of rice in the wet season. In the dry season, the picture is more diverse, but rice in this area is certainly not a rich people's grain. Millet and sorghum consumption is down to a share of 7 percent of calories in the wet season, but accounts for 25 percent in the dry season. Groundnuts emerge as a major food crop, providing an even higher share of calories than millet and sorghum in the wet season (7.4 percent) and 13.2 percent in the dry season. In the wet season, groundnut consumption shows a positive relation to income, but this is not the case in the dry season. All other foods (apart from cereals and groundnuts) provide 16 percent of calories consumed in the *sinkiros*. Sugar and oil dominate among these sources.

Substitution between Rice and Coarse Grains

The sample averages are biased toward rice growers because of the location in which the survey was carried out and the survey's task of assessing the effects of technological change and commercialization of rice production. A designation of villages by location in Table 41 provides information that is more generalizable for The Gambia. The villages outside the project area are lowland villages not affected by the project, and the upland villages were little affected by it. Still, rice is the main calorie source in all these groups of villages, especially in the wet season. In the dry season, upland village groups consume 42 percent of their calories from millet and sorghum before moving to purchased rice when their millet stocks are exhausted (Table 42). In none of the villages does rice provide less than 44 percent of all calories in the wet season, while village averages range between 16 and 67 percent in the dry season. These findings on food consumption patterns suggest for food policy that a focus on rice may be quite sensible, as rice is of vital importance in the diet, especially for the poorest segments of the rural Gambian population. Differences in these cereal consumption patterns by household appear to be largely driven by local and household-level availability. Households readily substitute between the two major types of cereals—rice and millet/

Table 41—Sources of calories consumed in households in project and nonproject villages, by season, 1985/86

Source	Wet Season 1985			Dry Season 1986		
	Lowland Villages	Upland Villages	Villages Outside Project (Lowland)	Lowland Villages	Upland Villages	Villages Outside Project (Lowland)
	(percent of total calories consumed)					
Rice	71.6	53.0	71.2	58.8	25.3	46.7
Millet, sorghum	1.7	15.9	4.1	15.5	42.1	22.5
Maize	0.8	4.6	0.4	0.8	3.2	4.8
Total cereals	74.1	73.5	75.7	75.1	70.6	74.0
Groundnuts	5.0	12.5	4.0	9.5	19.8	11.3
Sauce ingredients	0.9	0.9	1.1	0.8	0.8	0.8
Vegetables	1.2	1.3	1.0	0.7	0.5	1.2
Oil	4.4	2.4	2.5	3.7	1.9	1.7
Fish	3.3	1.9	2.9	3.2	2.5	1.6
Meat	2.2	1.6	3.7	1.6	1.7	3.2
Milk	2.5	2.4	2.0	0.7	0.3	1.5
Sugar	6.0	3.5	6.8	4.4	1.8	4.5
Other	0.6	0.2	0.3	0.4	0.2	0.3
(Average calories/day/adult-equivalent person)	(2,386.0)	(2,656.0)	(2,390.0)	(2,589.3)	(2,900.7)	(2,321.6)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

sorghum—within the year. This is visible at the village level, too. Millet and sorghum are the dominant sources of calories in the dry season in four of the eight participant villages. In these villages seasonal consumption switches between coarse grains and rice. In Sinchou Abdou, for instance, the rice share of calories moves between 67 percent and 27 percent in the wet and dry seasons, respectively, and in Sare Samba Sumali, between 78 percent and 25 percent. The villages that grow more rice also mainly eat rice year-round. Pacharr, Dasilameh, and Sukurr are such cases, with low shares of millet and sorghum consumption—from 0.1 percent to 11.0 percent between seasons. These villages have the highest access to project rice land by virtue of their status as traditional rice growers.

Consumption patterns throughout a season seem to be driven by availability, which is in turn determined by labor productivity in alternative grains. Enhanced supply of upland cereals, possibly as a result of yield-increasing technology, would face minimal demand constraints according to current consumption behavior. Replacing rice, especially in the dry season, appears to be fairly straightforward in this rural setting. However, the substitution of coarse grains for rice may be lower in urban areas of West Africa (Reardon, Delgado, and Thiombiano 1987). Price ratios and the time involved in food preparation (pounding millet takes considerably longer than pounding rice) do, of course, also affect the demand for millet and sorghum in rural areas, but mainly in the wet season when cash is less available and women's time more scarce.

If labor productivity in rice is increased by the rice project, consumption will shift more toward rice in households that have access to the new technology. Local trade does not level out the differences in availability by type of cereal crop over the seasons. To a large extent, one eats what one has grown. Limited trade of cereal-for-cereal takes place. There appears to be little desire to have a more frequent change in the cereal diet. When the millet-growing compounds have nearly exhausted their millet stock,

Table 42—Major sources of calories, by village and season, 1985/86

Village	Wet Season 1985				Dry Season 1986			
	Total Calories/ Adult-Equivalent Person/Day	Rice	Millet, Sorghum	Ground- nuts	Total Calories/ Adult-Equivalent Person/Day	Rice	Millet, Sorghum	Ground- nuts
		(percent of total calories)				(percent of total calories)		
Lowland villages in project								
Pacharr	2,372	75.6	0.1	5.0	2,748	65.5	11.1	8.2
Dasilameh	2,346	65.4	1.3	4.5	2,230	66.6	5.1	6.8
Sinchou Abdou	2,537	67.3	10.7	7.3	2,352	27.3	46.5	19.6
Sare Samba Sumali	2,450	78.2	1.1	4.1	3,404	25.3	47.0	16.7
Upland villages in project								
Njoben	2,603	44.1	20.8	15.8	2,719	16.1	56.1	19.3
Kussalang	2,875	65.9	16.8	4.0	3,492	24.2	35.4	21.8
Sukurr	3,176	59.5	3.6	16.5	2,811	46.5	1.8	20.2
Sare Bala	1,904	75.6	0.0	2.2	3,032	54.7	22.4	18.3
Villages outside project area								
Teneng Fara	2,608	66.9	6.3	4.4	2,579	38.7	28.8	11.1
Touba N'ding	2,134	75.8	1.6	3.6	2,018	56.0	15.1	11.5

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

they enter the market in the wet season, which implies the purchase of rice—identified in Chapter 5 as the primary traded cereal.

Effects on Calorie Consumption

A better understanding of the complex chain of links from technological change with commercialization through income to consumption can provide guidance on policy and programs for improved nutrition through agricultural development. The following analysis of the determinants of calorie consumption sheds further light on this.

A calorie-consumption model is specified and estimated separately for each of the two main seasons—wet (1985) and dry (1986). The dependent variable is the total calorie consumption per adult-equivalent person in each *sinkiro* (CALAE), which consists of the common *sinkiro* food and the snack food (derived from the recall surveys). Conventional demand theory leads to the hypothesis that calorie consumption is determined by income level (INCOME)—with a decreasing effect as income rises (INCOMESQ)—and market price of the major traded staple (RICEPR). Only the rice price, not other grain prices, is included in the model, because of the dominating role of rice and correlation with prices of other calorie-rich foods.

In the context of the marketed surplus model (Chapter 5), the problem of prices being potentially endogenous to type and scale of transaction and household income was alluded to. In the marketed surplus model, village mean prices were used because of variation of prices over the season. Seasonality is eliminated in this consumption model, as it is based on information covering one week in each season and the models are run separately for the two seasons. Intravillage price variation is larger than inter-village variation. An attempt was made to explain this price variability by household income, size of purchased quantity (scale effects), and distance to markets, which did not result in significant parameters for any of these variables. If there were endogenous relationships, a two-stage least square simultaneous estimation of price and quantity relationship would be called for. The observed price variability between households in the same village at the same time is due to factors such as discount transactions between relatives and friends inside or outside the village and acquisition of rice at different prices by household members traveling in the area or even to one of the distant cities. The actual price paid by the households was thus used in this calorie consumption model.

From larger *sinkiro* populations, positive scale effects due to less waste (SIZE) are expected in organizing food consumption, for instance. It is hypothesized that a higher share of cereals produced under women's control (WOMCER) has a positive consumption effect beyond the income effect of cereal production. This hypothesis is suggested by anecdotal indications that women's preference for spending income that they control on basic food is higher than men's. It would imply that women's *relative* loss of access to rice land leads to less-than-expected positive income effects of the new rice on consumption.

Somewhat related to this hypothesis, a test was conducted if an increased share of income in the form of cash (CASHIN) reduces the consumption of calories when income level is controlled for. This hypothesis is based on the notion that cash may end up in nonfood expenditure or purchased luxury foods to a larger extent than does subsistence food income. This may come about because of transaction costs and a different attitude of household members toward spending cash versus in-kind (food) income. It should be noted that much of the cash income is from groundnuts and comes in a lump sum.

It was further hypothesized that available food in storage (STORAGE), in the context of expected annual current income, determines offtake and thus calorie consumption,

especially in the wet season. Storage levels relate very little to income, as described in Chapter 5 (Table 27). Wet-season storage levels are largely determined by access to fully water-controlled rice in the project (apart from some large millet farmers).

Due to the apparent local differences in consumption, a variable was introduced that separates the lowland from the upland villages (LOCATION).

The per capita consumption information that forms the dependent variable involves knowing how many people attended *sinkiro* meals. As described above, the number of adults and weaned children eating each meal was recorded. When calculating "adult equivalents," a child was counted as 0.762 of an adult (men = 1, women = 1). Thus, for the calories-per-adult-equivalent variable—other than for the demographic structure of the compound personnel aggregated into adult equivalents used elsewhere in this analysis—a simpler weighting of persons had to be applied. The adult equivalents so formed are somewhat crude, but as many *sinkiros* were large, more detailed records of the age and sex of persons attending each meal was impracticable. To correct for further differences in demographic composition, (j) variables representing the population of the *sinkiros* (DEMOGR) were included at the beginning of each survey round. This allows accounting for variations both in the total size and in the precise age and sex composition of individual *sinkiros*. The analytical approach chosen here has the advantage that it is left up to the estimation procedure to determine differences from norm data whose applicability to the location remains questionable.²⁸ The stated hypotheses lead to the following model specification with each *sinkiro* (i):

$$\begin{aligned} \text{CALAE}_i = f(\text{INCOME}_i, \text{INCOMESQ}_i, \text{RICEPR}_i, \text{STORAGE}_i, \\ \text{WOMCER}_i, \text{CASHIN}_i, \text{LOCATION}_i, \text{DEMOGR}_{ij}). \end{aligned} \quad (16)$$

The model results are presented in Table 43. The following findings can be highlighted:

1. Calorie consumption is significantly income elastic, but with increased income the increase in calorie consumption is reduced, as indicated by the negative parameter estimated for the squared income term. The role of income for calorie consumption is more pronounced in the hungry season. A 10.0 percent increase in total annual income—at sample means—leads to a 4.8 percent increase in wet-season calorie consumption, but to only a 3.7 percent increase in calorie consumption in the dry season, when most households are well supplied with food.

2. An increased rice price, which stands for an index of cereal price, reduces calorie consumption as expected. In the wet season, a 10.0 percent price increase would reduce calorie consumption by 2.6 percent. The increased supply of rice due to technological change, with its likely price-depressing effect, can therefore be expected to have favorable consumption effects due to the price effect.

3. A reduced share of cereals from women's production reduces calorie consumption significantly in the wet season. Thus the shifting of women's *kamangyango* (private crops) and female-controlled *maruo* (communal crop) to the control of the compound head leads to reduced calorie consumption once income levels are controlled for.

²⁸ On the basis of a detailed activity survey in the village of Keneba (The Gambia), Roberts et al. (1982, 668-678) found that during the dry season lactating women were active 55 percent of the working day. In the early rainy season, this figure increased to 92 percent. For pregnant women, it was observed that activity increased from 50 to 83 percent in the rainy season.

Table 43—Calorie consumption models for wet and dry seasons

Variable*	Wet Season		Dry Season	
	Parameter	t-Value	Parameter	t-Value
INCOME	1.59329	7.218	0.94939	3.341
INCOMESQ	-2.067E-04	-5.316	-4.43508E-05	-0.853
RICEPR	-572.59043	-1.590	-635.95121	-2.030
STORAGE	4.26204	1.702	0.39015	0.464
WOMCER	321.83780	2.088	-57.30427	-0.264
CASHIN	67.74398	0.444	556.30173	1.707
LOCATION	-360.16405	-3.721	-319.89069	-1.994
SIZE	-16.89481	-1.149	-36.76049	-3.374
WOMSH	817.08670	1.823	1,478.36650	3.536
CHLD5SH	624.70833	1.038	553.32630	0.961
CHLD10SH	834.17860	1.812	626.22141	1.277
CHLD14SH	981.11329	1.867	1,364.50750	2.187
Constant	1,616.86638	2.937	2,755.13502	3.612
R ²	0.37		0.37	
F-value	9.65		9.72	
Degrees of freedom	197		197	

Notes: Dependent variable—calorie consumption per adult-equivalent person per day in respective season. A *sinkiro* is a cooking and consumption group within a compound.

* Definitions of variables:

- INCOME = total expenditure (as income proxy) per adult-equivalent person for year 1985/86 (in dalasi);
- INCOMESQ = income squared;
- RICEPR = rice price in dalasi/kilogram actually paid for purchases by household (if no purchase, village mean price of season);
- STORAGE = storage of all grains (in rice equivalents) per adult-equivalent person in respective season;
- WOMCER = share of cereals produced in *sinkiro* under women's control: 1985 wet-season estimation uses harvest from 1984 wet season and 1985 dry season; 1986 dry-season estimation uses 1985 wet-season harvest;
- CASHIN = share of cash income over total income earned by *sinkiro* in respective season;
- LOCATION = dummy variable = 1, if lowland village (else = 0);
- SIZE = size of *sinkiro* in adult-equivalent persons;
- WOMSH = share of women in adult-equivalent persons;
- CHLD5SH = share of children under 5 years of age in adult-equivalent persons;
- CHLD10SH = share of children 5-10 years of age in adult-equivalent persons; and
- CHLD14SH = share of children 10-14 years of age in adult-equivalent persons.

Maintained or expanded control by women of the cereal crop (rice) when production increases with new technology would have a beneficial effect for calorie consumption. If beneficial net effects for calorie consumption are to be achieved, given the changes in crop control, the income growth from technological change in rice must be higher to compensate for this adverse intrahousehold effect. A drop of women's share in cereal production from 30.0 percent (the sample mean) to 10.0 percent (the share in many *sinkiros* with pump-irrigated rice in the project) would, holding income constant, reduce per capita calorie consumption by 64 calories per adult equivalent, or 2.2

percent in the wet season. (The effect is not significant in the dry season when supplies are high.) To compensate for this with a higher income—given the estimated income elasticity of calorie consumption—would require an increase of 4.6 percent in income. This is much less than the income increase of about 13.0 percent estimated earlier that is due to the new technology in lowland villages. The relative diversion of income from calories after women lose control of rice is therefore less than the favorable effect for calorie consumption deriving from a higher total household income. The trade-off exists, however, and although clearly recognized as a net improvement on average, may not always bring this result.

4. An increased share of cash income does not, as hypothesized, reduce calorie consumption once income is controlled for. In the dry-season model, it turns out to be just significantly positive. More cash income in total income increases calorie consumption beyond the income effect (it should be noted that the cash share in total income is not correlated with total income [$r = -0.005$]). In the wet-season model, no significant effect of cash income beyond total income is found. More cash income does find its way into calories for the *sinkiro*, and these are to some extent in the form of snack foods. Increased monetization of the economy in this West African setting does not appear to be adverse for food consumption.

5. Larger *sinkiros* consume significantly less per adult-equivalent person. In a *sinkiro* with 20 adult equivalents versus one with 10, every adult (equivalent) person uses 5.8 percent fewer calories in the wet season and 11.7 percent fewer in the dry season. One interpretation suggests that these are the favorable effects of economies of scale. However, an alternative interpretation can be that in larger *sinkiros* various subgroups of the family may not obtain as much food as in smaller *sinkiros*. Children may end up more neglected. This hypothesis is tested further in the following nutritional status analysis.

6. The demographic variables show that the variable representing women's share in the number of adult equivalents in the household is positively significant. This is so even though women were weighted equally to men in the adult-equivalent count of meal participants. One likely interpretation of this is that in *sinkiros* with a high proportion of women there is more female labor available for food preparation and more food is, therefore, prepared and subsequently eaten. Another interpretation is that women, with their relatively heavy energy expenditure and easy access to the kitchen, actually do need and eat more than men.

At higher income levels, *sinkiros* spend absolutely and relatively more on expensive food items, such as meat and palm oil (see Table 33). This means that the per calorie cost of the diet rises. The differences between income groups are particularly pronounced in the wet season, when the poor economize on consumption by a switch to a lower-cost diet, a tendency that is less usual among higher-income groups. In the wet season, the lowest quartile spend 31 percent less per calorie than the top quartile as a result of dietary choices, but in the dry season, only 21 percent less (Table 44). Spending per 1,000 calories increased from D0.66 to D0.99 between the two seasons, which partly reflects price inflation (the average rice price went up from D1.33 to D2.05 per kilogram) and partly is the consequence of a change in diet composition. In the poorest quartile the unit cost of calories increased by 66 percent from wet to dry season (which is 8 percent more than the rice price increase). In the top quartile, the per calorie cost increase was 44 percent. Thus it is the lower income groups that bear the main burden of adjustment to (seasonal) price and income fluctuations (see also Table 35).

Table 44—Unit cost of calories, by income quartile and season, 1985/86

Income Quartile*	Unit Cost per 1,000 Calories Consumed by Group		Increase from Wet Season to Dry Season
	Wet Season 1985	Dry Season 1986	
	(dalasi)		(percent)
Lowest	0.56	0.93	66.1
Second	0.60	0.91	51.7
Third	0.65	0.94	44.6
Highest	0.81	1.17	44.4
Average	0.66	0.99	50.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

* Expenditure is used as a proxy for income.

NUTRITIONAL EFFECTS

Children in The Gambia are considerably affected by malnutrition. There are complex interactions between seasonality in food production, health environment, mothers' activity patterns, food availability, and household income that affect child nutrition. The chain that leads to high prevalence rates of malnutrition and high mortality rates among children begins with low birth weights and early growth faltering due to an adverse health environment and their mothers' time constraints in the wet season. The low birth weights result from increased stress on pregnant women due to high energy expenditures (at peak of fieldwork) and low intakes in the wet season. Similarly, seasonal energy stress reduces breast milk production, which then reduces weight gains in older babies (Prentice 1980, 167-183). Toddlers and children are affected by the quantity and quality of food available and by the frequency of meals served in the *sinkiros*. For them, household-level calorie availability may be of more direct relevance for nutritional status than the indirect effects of income generation and the nutrition and health status of mothers and caretakers.

Separating the actual effects of unsatisfactory food consumption from health problems (such as infectious diseases and diarrhea) remains difficult. It is probably their dynamic interaction, rather than a clearly separable cause and effect chain, that leads to the worrying nutritional deterioration of many children by the age of two years. The cross-sectional analysis that was performed on the basis of the survey has obvious limitations in capturing the dynamic interactions of health and nutrition.

As Payne (1987, 37) stresses:

For very young children, a major environmental stress is infectious disease. These not only induce some of the same kinds of physiological adjustments as direct food deprivation; they actually cause undernutrition by reducing appetite. Both together can produce changes in growth control mechanisms which are largely irreversible, resulting in major adjustments in body size of whole populations, the health implications of which are at present little understood, but which are only changeable over periods of generations.

Better understanding of the health-nutrition relationship is crucial for public policy aimed at improving both the household food and health entitlements. To further quote Payne on this issue:

At the level of the household, resource allocation decisions which take account of the child's need ought, however, to be based on a better understanding of the linkages between those two entitlement sets, and of the pivotal role of women (generally, not only mothers) in those decisions. Combining together the outcome of food deprivation and disease, as if these causes were interchangeable and indistinguishable, will not help in deciding for example whether women's labor time is better deployed in earning cash for more food, or controlling the disease transmission environment in the home, or spending time administering oral rehydration therapy.

Nutrition and Health in The Gambia and the Survey Area

No representative countrywide data on the prevalence of child malnutrition is available for The Gambia. The best alternative is data from growth monitoring by

Catholic Relief Services (CRS) of children participating in CRS nutrition schemes. Data for 1985 suggest that, according to the season, 33-45 percent of the children in the programs were below 80 percent of reference standard weight-for-age (Table 45).²⁹ As the program makes an attempt to target malnourished children—and does to some extent achieve this (Gambia 1985c)—the figures presented are probably higher than the actual national prevalence of malnutrition. The relative regional distribution of the CRS figures indicates an above-average prevalence in MacCarthy Island Division, which is the area of the IFPRI/PPMU survey.

Methods of Anthropometry Survey

The nutrition data of the IFPRI/PPMU survey are based on weight and height measurements of children under the age of 10 and their mothers. Age was carefully identified for those children who did not have a clinic card or other birth-date record. However, for children older than 6 years who had no record, age recall was sometimes problematic. All children in the survey population were measured once in the wet season (August-September 1985) and once in the dry season (February-March 1986) with the help of length-boards. Weights were taken at the same time. Height measurements were made with stachometers or length-boards (for those less than 24 months of age). Weight measurements were made with hanging scales (for children) or "bathroom" scales (for women). All measurements were made within the household by a

Table 45—Prevalence of malnutrition in The Gambia, by region and season, 1985

Region	Children Aged 0-5 Years Monitored by CRS*	Children Below 80 Percent of Weight-for-Age Among Those in CRS Schemes			
		January- March	April- June	July- September	October- December
		(percent)			
Western Division	15.1	25.0	27.0	32.0	37.0
Lower River Division	31.4	34.0	35.0	36.0	44.0
North Bank Division	29.4	34.0	32.0	39.0	47.0
MacCarthy Island Division	10.6	41.0	44.0	48.0	53.0
Upper River Division	12.9	36.0	39.0	36.0	47.0
Country average	14.8	33.0	34.0	38.0	45.0

Source: The data were provided by the Banjul office of Catholic Relief Services in a more disaggregated tabulated form.

* CRS = Catholic Relief Services.

²⁹ Field surveys such as the IFPRI/PPMU survey normally use weight and height (on their own or related to age) to describe anthropometric status. Height-for-age is a long-term measure of a child's nutrition and health experience, since it represents total growth achieved. A "stunted" child is one who is short for his age (that is, one who has grown inadequately). Weight-for-age reflects the total growth history of the child, but since weight can be rapidly lost (or gained), it is also influenced by the child's recent nutrition and health experience. Weight-for-height is usually considered the measurement that best expresses the child's present nutritional situation. The thin or "wasted" child is regarded as showing evidence of recent nutritional deprivation. These anthropometric measurements are compared with those found in a standard "reference" population (where food is freely available and health is good). Malnutrition is said to occur in those individuals whose measurements fall below defined cut-off points when compared with these standards. In the case of weight-for-age, children below 80 percent of standard are commonly classed as at least moderately malnourished (those below 60 percent are classed as severely malnourished).

specially trained and supervised team. Child identification was verified by enumerators familiar with the compounds.

Information on the structure and prevalence of malnutrition in the survey population is presented in this chapter. Thereafter, this information will be related to the technological change in rice production in a descriptive account. Subsequently, in multivariate analyses, an attempt will be made to explain differences in the nutritional status of children in order to identify efficient ways of improving nutrition and to clarify the potential role of agricultural development in this context.

For much of the presentation, the concept of "Z-scores" is used to express the extent to which a child's anthropometric measurements (weight-for-age, height-for-age, weight-for-height) deviate from median or average age-specific measures in a reference population. The Z-score is computed as follows for each child's observation:

$$\frac{\text{Actual child's measure} - \text{reference value}}{\text{Standard deviation of reference population}}$$

A Z-score of zero is "normal," although one must also allow for normal individual variation around that norm. Conventionally, a Z-score value of below minus 2 is considered malnourished. The World Health Organization/National Centre for Health Services standards are used here as references.

Nutritional Status in the Sample Population

The average values of Z-scores of the sample population show that children start on average with a normal weight, but that weight deteriorates rapidly in the 7-to 12-month age group, especially in the wet season (Table 46). This deterioration continues so that children of weaning age (13-24 months) have average Z-scores of -2. In fact, 50.7 percent of them are below -2. In this age group, a considerable degree of stunting prevails (see height-for-age, Table 46), combined with wasting (see weight-

Table 46—Nutritional status of children, by age group as measured by Z-scores, 1985/86

Age Group	Number of Observations		Height-for-Age Dry Season	Mean Values of Z-Scores			
	Wet Season	Dry Season		Weight-for-Age		Weight-for-Height	
				Wet Season	Dry Season	Wet Season	Dry Season
(months)							
1-6	46	39	0.07	-0.07	0.61	0.10	0.55
7-12	51	39	-1.40	-1.58	-1.19	-1.14	-0.11
13-24	75	80	-1.80	-2.02	-1.52	-1.33	-0.60
25-60	241	201	-1.39	-1.41	-1.33	-0.62	-0.57
61-120	299	284	-0.51	-0.90	-0.72	-0.78	-0.58
Totals							
1-120	712	643	-0.96	-1.17	-0.95	-0.75	-0.47
1-60	413	359	-1.33	-1.37	-1.15	-0.74	-0.41

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

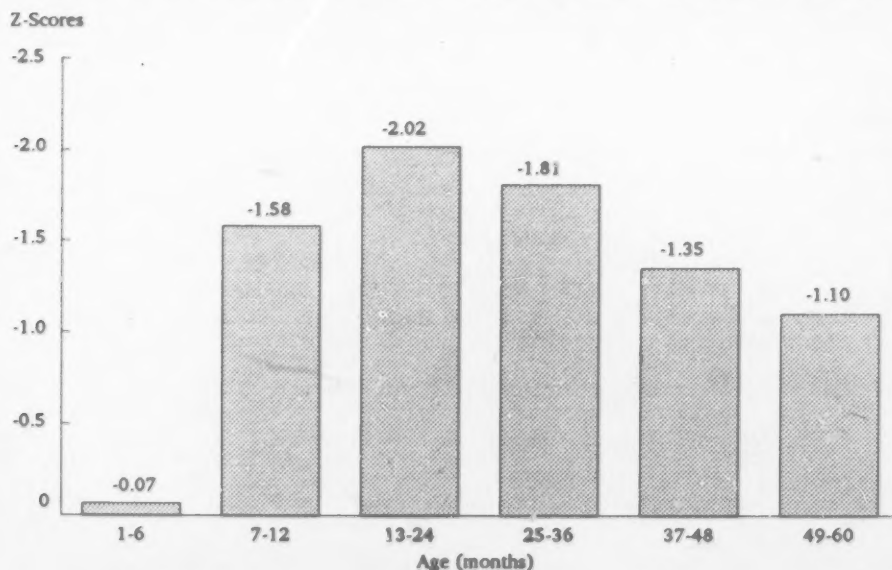
Notes: Wet-season data are for August-September 1985 (preharvest "hungry season"). Dry-season data are for March 1986.

for-height in Table 46). The situation appears to improve as children grow older (Figure 6), but this interpretation of the relative improvement in Z-score values after the age of 13-24 months may be misleading. Children with a particularly high degree of malnutrition are more likely to die at a young age, thus the average Z-score figure for the surviving children may rise. For instance, the average weight-for-age Z-score value of the 10 children (7-30 months of age) who died between the two survey rounds (July/September 1985-March 1986) was -2.98 in the first round, indicating very serious undernutrition, while the general average was -1.86 for this age group.

The percentage of malnourished children is higher in the wet season than in the dry season. In the wet season, 35 percent of the children aged 1-60 months were below 80 percent of the standard weight-for-age (Table 47). Those aged 7-24 months not only had the highest proportion of malnourished children but also showed the greatest seasonal variation. Children who are born late in the dry season or early in the wet season show a much worse nutritional status than children born at other times (Table 48). These "start conditions" of children determine their growth performance throughout their childhood. Significantly fewer children (by 24 percent) born in the "bad" season are among the living children in the sample. This may be partly a result of higher mortality of children born in this season. It may also be partly a result of planned seasonal birth spacing, or simply the result of seasonal patterns of leisure and pleasure. It is clear, however, that seasonality has profound implications for nutritional status. Given the rice project's effect on seasonal food supply and income, a positive effect might also be expected in the realm of nutrition.

In general, nutritional status is better in the dry season than in the wet season. This is especially true where weight-for-height indicators are concerned. However,

Figure 6—Weight-for-age of children aged 1-60 months, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Table 47—Prevalence of malnutrition of children, by age group

Age Group (months)	Height-for-Age, Dry Season, Less Than 90 Percent	Weight-for-Age				Weight-for-Height	
		Wet Season		Dry Season		Wet Season	Dry Season
		Less Than 60 Percent	Less Than 80 Percent	Less Than 60 Percent	Less Than 80 Percent	Less Than 80 Percent	Less Than 80 Percent
		(percent of children less than — percent of median)					
1-6	2.6	...	10.9	...	5.1	...	...
7-12	10.8	2.0	51.0	2.6	28.2	19.6	2.6
13-24	21.3	5.3	52.0	2.5	32.5	7.9	2.5
25-60	16.9	1.2	31.0	0.5	27.3	3.7	1.5
61-120	5.2	1.0	25.7	...	16.3	4.3	1.4
Total 1-120	10.9	1.5	31.1	0.6	21.1	5.3	1.5
1-60	15.6	1.9	35.0	1.1	26.3	6.0	1.7

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

there are differences between villages. For instance, Njoben and Kussalang (two upland villages) show substantially less seasonal fluctuation in children's nutritional indicators than Pacharr or Dasilameh (two lowland villages highly involved in the project (Table 49)). Njoben and Kussalang were identified earlier as comparatively "rich" villages with high levels of food consumption. This may indicate that at high income levels the pronounced seasonal production fluctuations in upland villages are coped with more easily and have a limited effect on children's nutritional status.

This indication is supported by the nutritional data organized by income levels of households in Table 50. Especially the more long-term indicators of nutritional status (height-for-age and weight-for-age) are positively related to income level, and particularly for those aged 5-10 years. Seasonal differences tend to be higher among the poor. Overall, however, the results are hard to interpret in monocausal ways, given the host of factors affecting nutritional status. More refined approaches will therefore be applied to trace the income-consumption-nutrition relationships in regression analyses below.

With more rice land in the new project, the proportion of stunted children (low height-for-age) is smaller (Table 51). As far as weight-for-age is concerned, however, in the wet season greater access to the project's rice land is not associated with improved nutritional status. In both seasons, the highest proportion of children with poor weight-for-height was in the group with no project rice. It is clear that the data in Table 51 cannot be easily interpreted as a cause (project) and effect (nutrition) relationship. More rice land in the project may have various implications for the different factors

Table 48—Nutritional status of children aged 1-60 months, by season of birth

Indicator	Average Z-Score Values	
	Born During September- February ^a	Born During March- August ^b
Weight-for-age	-1.46	-1.72
Height-for-age	-1.22	-1.63
(Number of observations)	(204)	(156)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Late wet season and early dry season.

^b Late dry season and early wet season.

Table 49—Nutritional status of children aged 6-59 months, by village and season, 1985/86

Village	Average Weight-for-Height Z-Scores of Children 6-59 Months		Average Weight-for-Age Z-Scores of Children 6-59 Months	
	Wet Season	Dry Season	Wet Season	Dry Season
Lowland villages in project				
Pacharr	-0.99	-0.54	-1.60	-1.39
Dasilameh	-0.84	-0.59	-1.60	-1.34
Sinchou Abdou	-0.75	-0.54	-1.60	-1.35
Sare Samba Sumali	-0.92	-0.46	-1.35	-1.37
Upland villages in project ^a				
Njoben	-0.75	-0.70	-1.51	-1.55
Kussalang	-0.48	-0.46	-1.34	-1.18
Sukurr	-1.38	-0.43	-1.72	-1.22
Villages outside project area (lowland)				
Teneng Fara	-0.73	-0.77	-1.22	-1.19
Touba N'ding	-0.39	-0.23	-1.79	-1.59
Total average	-0.81	-0.57	-1.56	-1.41

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a The village of Sare Bala is not included here because of limited numbers of observations.

that influence nutritional status. Income may rise and food availability may increase, thus a potential for improved nutrition is there. On the other hand, mothers' time may be more constrained and child-care quality may suffer due to work load. Also, small children carried more frequently to the project fields by their mothers may be exposed more to malaria. This project uses ponded water, which in some situations presents a health hazard. The net effect of such factors will be addressed in the model analysis below, which also tests for the statistical significance of the apparent differences diagnosed

Table 50—Prevalence of malnutrition among children, by household income level and season, 1985/86

Indicator	Age Group	Season	Income Quartile ^a				Average
			Lowest	Second	Third	Highest	
			(percent of children)				
Less than 90 percent Height-for-age	6-59	Wet	30.1	13.8	13.1	14.3	17.1
Less than 80 percent Weight-for-age	6-59	Wet	40.5	37.9	36.9	39.3	38.5
Weight-for-age	6-59	Dry	28.3	30.1	36.3	20.8	28.8
Weight-for-height	6-59	Wet	9.3	6.0	5.9	7.1	6.9
Weight-for-height	6-59	Dry	5.7	1.0	2.7	0.0	2.0
Less than 90 percent Height-for-age	60-120	Wet	11.0	5.6	7.7	3.0	6.9
Less than 80 percent Weight-for-age	60-120	Wet	32.8	29.2	24.3	15.2	25.8
Weight-for-age	60-120	Dry	16.7	19.0	20.6	10.5	16.7
Weight-for-height	60-120	Wet	4.1	5.6	2.6	4.6	4.3
Weight-for-height	60-120	Dry	0.0	1.3	2.7	1.3	1.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Total expenditures per capita per year is used as an income proxy.

Table 51—Prevalence of malnutrition among children aged 6–59 months, by access to project land and season, 1985/86

Indicator	Season	No. Project New Land	Level of Compound Access to Project Land*				Average
			Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	
(percent of children)							
Less than 90 percent Height-for-age	Wet	33.3	17.1	16.9	13.2	14.0	17.1
Less than 80 percent Weight-for-age	Wet	30.0	37.7	33.7	43.4	45.6	38.5
Weight-for-age	Dry	17.8	33.2	34.2	26.8	21.4	28.8
Weight-for-height	Wet	12.9	5.7	6.7	7.8	5.3	6.9
Weight-for-height	Dry	3.6	1.2	2.4	1.8	1.8	2.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Pump-irrigated land equivalent per adult-equivalent person.

in the above tabulations. It is noteworthy that mean values and prevalence rates of nutritional status and malnutrition are not the only changes in association with socioeconomic and health-related variables—the whole distribution pattern also changes, as highlighted in Figure 7. The distribution of weight-for-age Z-scores of the child population from compounds with most access to new rice land is considerably shifted into the ± 1 Z-score area and no longer looks normally distributed.

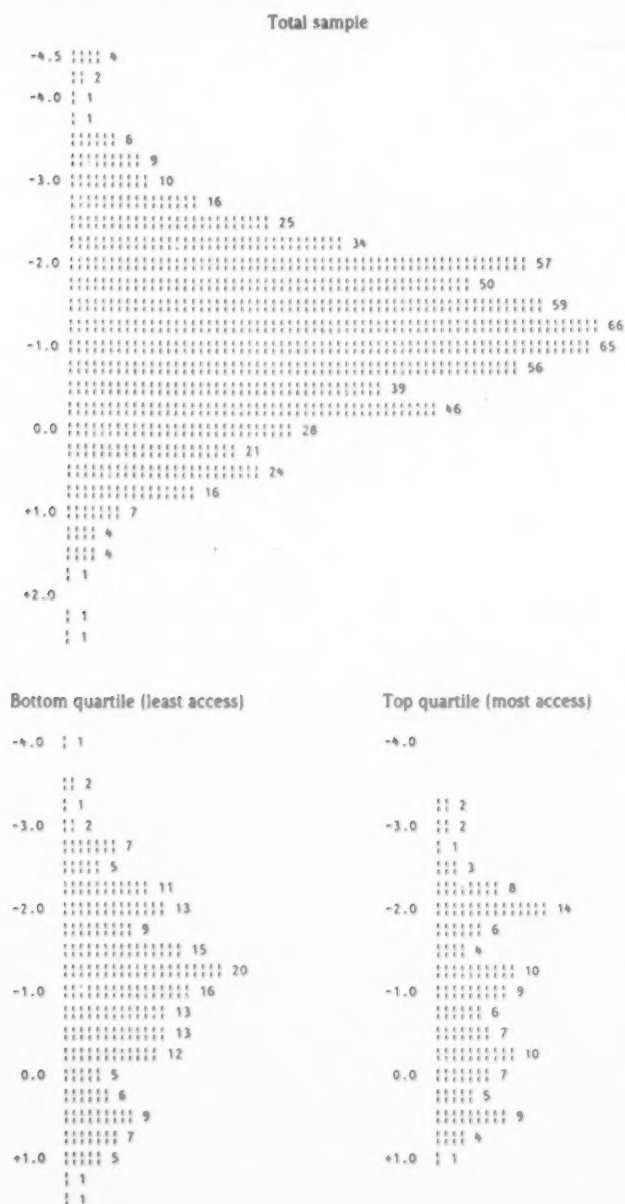
Prevalence of morbidity and mortality does not show a clear association with access to new rice land. Child mortality appears to decrease with access to more rice in the project. Diarrhea prevalence shows no difference between the top and bottom quartiles; fever (malaria), however, appears to increase. It should be noted that the population with most access to the project already lives close to the swamps, which are traditionally malaria-prone.

Mothers' Nutritional Status and Time Allocation

Mothers' health, activity patterns, and time allocation are of greatest importance for children's nutritional performance. To get an indicator of their nutritional status, the weights and heights of mothers were measured in the wet and dry seasons along with those of their children. Mothers were also interviewed about their own and each of their children's health (and health care), using a recall of symptoms and a record of types of treatment for the preceding four weeks. Also, a week's recall of mothers' allocation of time (time spent away from the compound) by type of activity was effected during each survey round.

Women's body weight fluctuates on average by at least 2.20 kilograms between the wet season and the dry season (Table 52). The fluctuation is about twice as high in absolute and relative terms in the upland villages as in the lowlands. Phillips, Coles, and Seaman (1982) found annual fluctuations in body weight of at least 3.46 kilograms for women, although the comparable figure for men was only 2.11 kilograms. This fluctuation in weight is a result of seasonal imbalances between the energy intake and energy expenditures of women. It has profound implications for children's health and growth performance. A reduction of this stress on mothers in the wet season by means of increased food consumption and reduced work load could be expected to have favorable effects not only for the mothers, but for their children as well, particularly the babies. With increased project involvement, women's weight fluctuations are reduced (Table 52).

Figure 7—Distribution of weight-for-age Z-scores of children aged 7-120 months, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Table 52—Nutritional status of mothers in the wet and dry seasons, by level of access to project land, 1985/86

Level of Access to Project Land	Change in Mean Weight from Wet to Dry Season	Weight-for-Height in Dry Season	Change in Weight-for-Height from Wet to Dry Season
	(kilograms)	(kilograms/100 centimeters)	(percent)
Lowest quartile	+ 2.9	34.6	+ 5.4
Second quartile	+ 2.6	33.5	+ 4.8
Third quartile	+ 1.7	33.2	+ 3.0
Highest quartile	+ 1.1	34.1	+ 1.8
Average	+ 2.2	33.9	+ 4.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Women's reduced weight stress over the seasons may be seen as a substantial benefit of the new technology in rice (that is, the second crop) that levels out seasonal fluctuations in production and, therefore, consumption. A look at women's activity patterns sheds more light on this.

Women from lowland villages spend more time away from the compound and a higher share of that time working in field crops than women from upland villages. Rice plays a dominant role in this pattern. In the wet season, lowland women worked 61.4 percent of their available work time away from the compound, and upland women, 47.1 percent. In that main cropping season, lowland women spent 70.5 percent of their time working outside the compound in rice and a total of 78.6 percent in crop production. Upland women, on the other hand, spent 9.3 percent of their time on rice and a total of 71.7 percent in crop production. Thus, lowland women (mostly Mandinka and Serahuli) work an average of 44.0 percent more in field crops than upland women (mostly Fula and Wolof).

With increased access to the rice project—which largely coincides with village location in lowlands—women spend more of their time away in the rice fields (for example, 16.2 percent in the lowest quartile and 74.1 percent in the highest quartile [Table 53]). Accordingly, an almost linear substitution occurs with upland crops in the wet season.

To a surprisingly large extent other activities also lead women to work away from the compound during the dry season when there are no crops in the upland fields. This results in a rather low degree of seasonality in total time spent away from the compound. Thus, women from compounds with greater access to rice land in the project spend equal amounts of overall work time away from home during both seasons. Work in project rice and upland cereals is balanced with nonfarm activities. That is, nonfarm activities almost completely substitute for the reduced labor demand from upland fields in the dry season (Table 53).

How does this time allocation affect child care? Information compiled in Table 54 shows that women from compounds with more rice land in the project tend to take their older children (above 18 months) less frequently with them to the field. However, the children remain attended, if only by older children and other women in the compound. The pattern changes in the dry season when women's time is less scarce; older women rather than older children are then the main caretakers when the mother is away. Apparently, child care by older children is the less-desired choice, but the work load in the wet season often leaves no other option. Also, in the dry season, babies are much less frequently

Table 53—Allocation of women's time away from the compound, by level of access to project land, 1985/86

Time Allocation	Level of Access to Project Land							
	Lowest Quartile		Second Quartile		Third Quartile		Highest Quartile	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
Time away from compound per week (in workday equivalents)	3.4	2.5	4.3	4.1	4.1	3.8	4.0	3.9
Time away from compound during day (in percent of a seven-day week)	48.6	35.7	61.4	58.6	58.6	54.3	57.1	55.7
	(percent of above time)							
Work in rice fields	16.2	6.5	51.9	54.2	61.4	62.3	74.1	61.1
Work in fields of upland crops (grains, groundnuts)	51.4	...	28.3	...	12.7	...	4.7	...
Other farming, vegetables	3.2	5.6	1.5	3.8	...	1.3	0.1	1.1
Other activities (such as fetching water, firewood, marketing)	29.3	87.9	18.3	41.9	25.9	36.1	21.1	37.8

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: Parts may not add to totals because of rounding.

taken by the mother, but rather are left at home. Provision of child-care facilities in the wet season would assist women in increasing their labor productivity.³⁰

Determinants of Nutritional Status and the Role of New Rice Production

If nutritional improvement is an objective of agricultural development, improved knowledge about the relationship between the two is of crucial relevance for appropriate program and project design. The following analysis attempts to explain children's nutritional status and its change in the context of food consumption and the health and sanitation environment of the compounds in which they live. The link to agricultural development (that is, rice) is established with the analyses in Chapters 5 and 6, in which the income and food consumption effects of technological change and commercialization were assessed (see also conceptual framework, Chapter 2, equation [8]).

The nutritional status variables to be explained in the model are Z-score values of (1) height-for-age, representing the more long-term result of food and health environment to which the child was exposed; (2) weight-for-age, representing an intermediate measure, as weight is also positively related to height (which is more a result of malnutrition and disease episodes in the past); and (3) weight-for-height, representing the short-term (acute) nutritional situation.

The explanatory variables of the model consist of four different blocks:

- Food consumption-related variables—
calorie consumption of the *sinkiro*

³⁰ Day-care centers located around the rice project were an attempt to fill this apparent need.

Table 54—Pattern of child care when mother was away from compound, by age of child and season, 1985/86

Child Care When Mother Was Away ^a	Age of Child (Months)					
	0-6	7-12	13-18	19-24	25-30	31-60
	(percent of children)					
Wet season						
Total sample						
Taken with her	68.9	41.2	37.5	31.4	13.2	21.7
Left with other women in compound	13.3	17.6	17.5	28.6	13.2	29.7
Left with other women in other compound	4.4	2.0	2.5	2.9	10.5	3.4
Left with father	...	...	5.0	...	2.6	1.7
Left with other children	8.9	39.2	35.0	34.3	55.3	29.7
Left on its own	...	...	2.5	2.9	2.6	11.4
Left with others	4.4	...	...	...	2.6	2.3
By access to new fields in project						
Taken with her						
Lowest quartile	58.3	37.5	70.0	66.7	33.3	46.2
Second quartile	66.7	43.8	11.1	18.2	11.1	25.0
Third quartile	60.0	28.6	30.0	33.3	...	7.5
Highest quartile	77.8	60.0	33.0	...	...	...
Dry season						
Total sample						
Taken with her	57.9	30.6	11.9	12.1	...	1.3
Left with other women in compound	23.7	35.9	52.4	57.6	75.0	42.7
Left with other women in other compound	2.6	2.6	2.4	9.1	...	4.0
Left with father	...	...	4.8	...	...	0.7
Left with other children	13.2	30.8	28.6	15.2	21.4	32.7
Left on its own	...	...	...	...	3.6	16.7
Left with others	2.6	...	...	6.1	...	2.0
By access to new fields in project						
Taken with her						
Lowest quartile	66.7	33.3	28.6	25.0	...	...
Second quartile	70.0	50.0	6.7	11.1	...	2.6
Third quartile	50.0	33.3	...	...	...	2.9
Highest quartile	60.0	28.6	...	...	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a During the week preceding the interview.

- Health- and sanitary-related variables—
 - prevalence of sickness (for example, diarrhea)
 - quality of village drinking water
- Demographic environment of household—
 - size of *sinkiro*
 - number of children in *sinkiro*
- Individual child's demographic characteristics and history—
 - sex
 - age
 - born in "bad" season
 - child of the compound head
 - mother's height

Besides these factors, account is taken of the accuracy of information obtained by controlling for data on birth dates actually documented versus those only estimated by the mother. Finally, an evaluation is made of whether the degree of participation in the new rice project has an effect beyond the determinants mentioned above. This is to test for secondary and indirect effects at work in the complex web of nutrition-consumption-health and child-care relationships. The data from both survey rounds are pooled in the model and separated by a dummy variable to account for seasonal effects besides those captured by the variables mentioned.

This leads to the model below, which is based on the following hypothesis. Increased per capita calorie consumption at the household level (CAL) also increases calorie consumption for children, who capture their own share of the greater availability. This increased consumption reduces the nutrition problem, but decreasingly so at the margin (CALSQ). If a child had diarrhea (DIAR) for an extended time preceding the survey date, its nutritional status has presumably deteriorated. An attempt is made to capture genetics (GEN) by mother's height (fathers were not included in the anthropometry survey). While short-term nutritional status is affected by diarrhea and related diseases, poor village water quality (WATER) is expected to have an adverse effect on the nutrition and health environment in which the child grows up. In large *sinkiros* (SIZE) and in *sinkiros* with a high share of small children (NCHILD), it is hypothesized that negligence in child care will have negative effects for child health and nutrition. On the other hand, it is hypothesized that children of the compound head (CHCHD) are better taken care of than others; the models test for differential nutritional performance of boys versus girls (SEX), and take account of the age-specific curvature of growth (AGE, AGESQ). As indicated by the earlier tabulations, it is hypothesized that children born in the "bad" season may suffer nutritionally (SBORN); from increased access to the rice project (RICPROJ), favorable income and consumption and, thus, nutritional effects are expected. These should be captured in the calorie consumption and in spending on health improvement. On the other hand, adverse effects are expected for women's income control and work load; time and income allocated to nutritional improvement may suffer because of that, and this effect—over and above the income consumption effect—is expected to be captured by the RICPROJ variable.

The model is thus as follows:

$$\begin{aligned} \text{NUTSTAT}_{i,s,r} = f(\text{CAL}_{s,r}, \text{CALSQ}_{s,r}, \text{DIAR}_{i,s,r}, \text{GEN}_{i,s,r}, \\ \text{WATER}_s, \text{SIZE}_s, \text{NCHILD}_s, \text{SEX}_{i,s}, \text{AGE}_{i,s,r}, \text{AGESQ}_{i,s,r}, \\ \text{SBORN}_{i,s}, \text{CHCHD}_{i,s}, \text{VERDAT}_{i,s}, \text{RICPROJ}_s, \text{DRYS}_r), \end{aligned} \quad (17)$$

where

VERDAT = verification of birthdate,
DRYS = observation in dry season,
i = child,
s = *sinkiro*, and
r = survey round (season wet, dry).

(For variables in general terms, see preceding text; for specific definitions, see Table 55.)

Explanatory power of this type of model in terms of R^2 is low, in general because of much variance in the dependent variables, which is due to genetics and the past health and nutrition history of children not captured in the cross-sectional analysis. It is more the levels and significance of estimated parameters that are telling. From the estimation results in Table 55, the following are highlighted:

Table 55—Determinants of nutritional status

Variable ^b	Weight-for-Age Z-Scores of Children Aged 7-120 Months ^a		Height-for-Age Z-Scores of Children Aged 7-120 Months		Weight-for-Height Z-Scores of Children Aged 7-120 Months	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
CAL	0.0091559	2.713	9.314474E-03	2.206	4.611568E-03	1.468
DIAR	-2.50525	-2.690	-4.05504	-3.480	-0.31224	-0.360
WATER	-0.01006	-2.248	-0.02183	-3.897	4.735614E-03	1.136
SIZE	-0.71560	-1.826	0.62056	1.266	-1.38726	-3.802
NCHILD	-0.10040	-0.547	-36.18402	-1.739	17.92066	1.157
SEX	-8.18773	-1.501	-18.33278	-2.685	1.84985	0.364
AGE	1.67620	4.308	0.72466	1.488	0.92144	2.543
AGESQ	-7.69439E-03	-2.426	1.513454E-03	0.381	-6.64467E-03	-2.250
SBORN	-13.64637	-2.480	-18.33008	-2.662	-3.49221	-0.682
GEN	1.85207	4.487	2.52886	4.896	0.22410	0.583
CHCHD	17.84216	3.074	14.89253	2.050	15.53760	2.874
VERDAT	-19.99746	-3.132	-34.58969	-4.329	4.81197	0.809
RICPROJ	-109.19153	-0.740	-110.01574	-0.596	-45.46775	-0.331
DRYS	19.29197	3.507	-0.69184	-0.101	26.61881	5.197
Constant	-467.02280	-6.746	-507.38817	-5.857	-160.14683	-2.484
R ²	0.164		0.162		0.072	
F-value	17.28		17.06		6.88	
Degrees of freedom	1,233		1,233		1,233	

^a Z-scores are multiplied by 100 in this analysis.

^b Definitions of variables:

CAL	= calories per adult-equivalent person per day from all sources, including snacks;
DIAR	= number of days of diarrhea in preceding four weeks;
WATER	= bacteria count of most-used well in village used for drinking water;
SIZE	= number of adult-equivalent persons in <i>sinkiro</i> (cooking and consumption group);
NCHILD	= number of children under 10 years of age over number of persons in <i>sinkiro</i> (ratio);
SEX	= sex of child (= 1, boys; = 0, girls);
AGE	= age of child in months;
AGESQ	= age of child in months squared;
SBORN	= If child born in "bad" season (March-August) (= 1, else = 0);
GEN	= height of mother in centimeters;
CHCHD	= If child is son or daughter of compound head (= 1, else = 0);
VERDAT	= If date of birth is verified by record (= 1, else = 0);
RICPROJ	= size of lands in new rice project in hectares of irrigated land equivalent per adult-equivalent person; and
DRYS	= If observation in dry season (= 1, else = 0).

• Increased food energy consumption reduces children's nutrition problem as expected.³¹ A 10 percent increase in calorie availability per capita in the *sinkiros* significantly increases the weight-for-age Z-score at the sample mean by 0.28 (2.4 percent). Increased calorie availability clearly has a very favorable effect for children's nutritional improvement. The respective elasticities of Z-scores with respect to calories are high

³¹ No significantly decreasing effect is found at the margin. The specification was therefore changed and CALSQ was dropped.

for all three nutritional status indicators. They range between 0.24 and 0.26 for the three indicators calculated at sample means.

- High prevalence of diarrhea is associated with a reduction in nutritional status. This is significant for height-for-age and weight-for-age, although not for weight-for-height. The latter part of this finding is curious, since one would expect the prevalence of diarrhea measured during the survey to have the greatest effect on the short-term indicator and less effect on the long-term anthropometric characteristic of the child. It may be, however, that the diarrhea variable represents underlying unhygienic conditions in the home.

- Children from villages with unclean drinking water—that is, where a high bacteria count was found in the water sample—were significantly more stunted (see height-for-age model). Frequent episodes of water-borne diseases can be assumed to be the cause of this.

- The parameter of mother's height, which is seen as a genetic indicator, contributes to explaining child's height-for-age and weight-for-age variance as expected.

- Increasing *sinkiro* size has a significantly negative effect on children's weight-for-age and weight-for-height. As the calorie consumption model showed, increased *sinkiro* size was associated with reduced calorie intakes per adult equivalent. Moreover, observations in large compounds (which tend to have the largest *sinkiros*) suggested that child care was particularly insufficient in these larger units. This implies that, while there may be positive scale effects in food consumption, there may be negative ones in producing child health and nutrition.

- Contrary to many Asian examples, boys here are found to be less well off than girls (height-for-age, weight-for-age). Yet there is a different bias; children of the compound head are significantly better off than others in the same family unit. Distribution of investment in children's health and nutrition is obviously not equal within compounds.

- Both weight-for-age and height-for-age are adversely affected in the long run if a child is born late in the dry season or early in the wet season. Children born in these periods are on average 8 percent more stunted (their estimated height-for-age Z-score is 8 percent less than the average).

- There are no indications that (degree of) access to the rice project has a negative or positive effect on nutrition beyond any of the factors already included in the model through which the indirect income-consumption effects show their positive effect on nutrition.

- The control variable that identifies the children without a written birth record suggests that mothers systematically tend to underestimate their children's age. A separate estimation of the same model for all the children with birth records did not significantly change the overall model results from those presented in Table 55. It is also noteworthy that mothers' height, which is partly genetically determined, has a highly significant effect for children's height and weight. The ethnic differences of height in the location are supposedly captured through this variable.

- Seasonality in weight loss is not fully explained by the consumption- and health-related variables in the model. Nutritional status in the wet season is estimated to be worse than in the dry season even after consumption and health variables are controlled for (DRYS).

In addition to the explanation of children's nutritional well-being, an attempt is made here to explain mothers' nutritional status in a model.

The dependent variable of this model is the weight-for-height (MWH; kilograms per centimeter) of mothers of the children in the sample. The considerable variance and seasonal fluctuation of women's weight, which is reflected in this variable, was described earlier. These differences and fluctuations are hypothesized to be determined

by women's food consumption levels (CAL) and by energy expenditure, as indicated by work load (WORKL). Only a rough indication is possible given survey data that cover women's activities for only one week in each of the two seasons. Above that, current health (SICK), pregnancy status (PREG), and individual status characteristics (compound head's wife, CHHUSB) are controlled for. The model is as follows:

$$MWH_{i,s,r} = f(CAL_{s,r}, CALSQ_{s,r}, WORKL_{i,s,r}, SICK_{i,s,r}, PREG_{i,s,r}, NOCHL_{i,s,r}, CHHUSB_{i,s}, DRYs_r), \quad (18)$$

where

NOCHL = number of children born,
CHHUSB = woman is wife of household head,
DRYS = dummy variable for dry season is 1,
i = woman,
s = *sinkiro*, and
r = survey round.

(For specific definitions of all variables, see Table 56.)

The results of the multivariate analysis show that household food energy consumption has a positive effect on mothers' nutrition, but the food consumption effect decreases at the margin.

Table 56—Determinants of mother's nutritional status: regression model

Variable ^a	Parameter	t-Value
CAL	3.735987E-03	3.524
CALSQ	-2.79431E-09	-1.564
WORKL	-8.47798E-04	-1.151
SICK	-6.21542E-03	-1.691
PREG	0.04032	4.496
NOCHL	3.735987E-03	3.524
CHHUSB	8.377180E-03	2.373
DRYS	0.01059	3.002
Constant	0.30493	16.824
R ²	0.080	
F-value	7.80	
Degrees of freedom	716	

^a Definitions of variables:

CAL = calories per adult-equivalent person per day from all sources, including snacks;
CALSQ = calories per adult-equivalent person per day from all sources squared;
WORKL = time spent working away from compound in day equivalents over one-week period;
SICK = if woman was sick during preceding four weeks (= 1, else = 0);
PREG = if woman is pregnant (seven months or more) (= 1, else = 0);
NOCHL = number of children born;
CHHUSB = woman is wife of a compound head (= 1, else = 0); and
DRYS = dummy variable for dry season (= 1).

The nutritional status of women who are wives of compound heads is significantly better than others. This indicates an unequal distribution of nutrition and health benefits among a compound's women, which was also found to be true for children. The seasonal effect on women's nutritional status is confirmed; women are significantly better off in the dry season.

To sum up, major findings of the nutritional effects of technological change in rice production include the following:

- The project raised household income, and thus calorie consumption, which in turn substantially improved the nutritional status of children. The shift in income control away from women has, however, somewhat limited the beneficial consumption effect.

- Mothers' weight loss in the wet season, which is not only a health and nutrition problem for the individuals but also indirectly for their children as it relates to low birth weight, was found to be reduced with increased access to the new rice land.

- The greater their access to the rice project, the more frequently mothers take their smallest children with them to the rice fields in the wet season. Since proximity to the swamps is associated with more sickness in children (that is, fever), there is a health problem that requires attention;³² the solution probably lies in appropriate supplementary program components for child-care support in the villages.

³² The percentage of children under five years of age found sick during the preceding four weeks of the recall period was 6.1 percent higher in the lowland villages than in the uplands, and the duration of sickness was on average 7.6 days in the villages close to the river compared with 4.8 days in the upland villages.

CONCLUSIONS FOR PROGRAMS AND POLICY

From this West African case study, generalizable conclusions are sought as guidelines for programs and policies designed to improve household-level food security and nutrition through technological change in agriculture and enhanced market integration. The attempt to generalize is made by confronting specific study findings with broader policy objectives and constraints. No attempt is made to outline a set of general prescriptions.

With the current situation of difficult economic adjustment in many African countries, programs need to be rigorously designed toward saving or generating foreign exchange, not creating a fiscal burden. Furthermore, in view of rising urban unemployment, there needs to be a focus on expanding rural labor demand and increasing productivity in agriculture (Mellor, Delgado, and Blackie 1987). These criteria may not necessarily be compatible with a narrowly defined focus on food self-sufficiency at the national level. For example, major irrigated rice schemes may use up resources that would make more rice—or other cereals—available if they were directed to other uses: minor irrigation, rainfed rice, other food crops, or exportable crops earning foreign exchange used to import food.

Agricultural growth fostered by technological change is documented in this study as a powerful force able to contribute toward the fulfillment of the above objectives and ultimately to the alleviation of poverty. While a strong positive relationship was established in this research between increased income, rising food consumption (from deficit levels), and nutritional improvement, there is ample scope for agricultural program design to maximize these welfare effects of agricultural growth by appropriate policy coordination in the fields of agriculture, infrastructure, and health.

Research on the rice project considered here has clearly shown that a narrowly focused promotion of output in one crop, through subsidized irrigation, did achieve increased production. However, this was achieved at high costs of investment and high opportunity costs of labor. The latter resulted from considerable output forgone from competing crops (other cereals and groundnuts) because labor, having high marginal productivity, was withdrawn from them.

Furthermore, it is shown that an understanding of the wider context of nutrition-deficiency problems and their causes is required in order to effectively mobilize program components for improvement of food security. The results stress that this should include paying more attention to seasonality in income and food availability, to women's work load, to the health situation, and to sanitation (water quality).

This is not to argue that individual projects should singlehandedly attempt to be "do-everything projects." Quite the contrary, given the past failures of many broad-based rural development programs in Africa. The research results stress, however, the importance of comprehensive policy coordination for rural poverty alleviation. To achieve effective nutritional improvement as a result of agricultural development programs, a complement in the form of health- and nutrition-related policies that combine long-term development concerns with a targeted short-term impact on nutrition is required. In countries dependent on farming, such as The Gambia, successful agricultural programs and policies have to provide the resources to fund such complementary measures and to make them sustainable in the rural sector.

Choice of Program Focus in Agriculture

Several factors may speak for a focus on rice in agricultural development programs in this West African setting: the irrigation-seed-fertilizer technology to promote rice is well known; rice is the main marketed cereal in rural and urban Gambia; in a country that imports 35 percent of cereals consumed, the import-substitution effect is favorable for the foreign exchange situation insofar as the chosen technologies permit incremental production at low foreign exchange cost; rice is particularly important as an income source for poor farmers in this area; and the rural poor get more calories from rice than do the upper-income groups.

However, the analysis of labor productivity by crop suggests that considerable scope exists for a multicrop focus rather than a single-crop focus. The analysis of the productivity of upland crops underlines the potentials of a policy that would move the agricultural production frontiers more broadly with functioning input delivery systems; that is, a fertilizer cum labor-saving implement program coupled with an effective rural credit scheme (explicitly open to women farmers or with a specific women's branch). Program planners need to be aware that the promotion of crops that compete with rice for labor and other resources (millet, maize, groundnuts) through broad-based policies for improved input delivery systems will further increase the opportunity cost of rice production. This calls for more attention to competition between crops for scarce labor resources and a less-narrow focus on physical output growth in a single crop.

The main commercialization effect of the new rice crop is driven on the input side by loan repayment requirements for fertilizer, seed, water charges, and land preparation services. The second effect is an expanding market for hired labor. The third is the marketed surplus from the new crop, which, however, was found to be rather low. While marketed surplus was found to be output- and price-elastic as expected, local infrastructure (that is, proximity to the road/markets) had a favorable effect over and above these elasticities. This stresses the potential role to be played by infrastructure in improving agriculture's integration into the exchange economy.

Choice of Technology for Rice

Since scarce water resources in the dry season limit the development of fully water-controlled rice, it is argued that more emphasis on the partly water-controlled rice technology for the wet season would be appropriate. Even if this type of rice does not have the positive smoothing-out effect on seasonal cereal supplies that is provided by a dry-season crop, it is still a more secure means of producing cereals than the purely rainfed upland farming. Women are more involved in this partly water-controlled technology, which appears second-best in terms of returns to labor from a farmer's perspective. Currently, this is largely because of the differential subsidies embodied in irrigation infrastructure allocated to the two rice technologies. The cost of production in this technology, however, has to come down substantially to be viable. Land-development cost in larger perimeters makes tidal and improved rainfed rice currently even more expensive than fully water-controlled rice in the Jahally-Pacharr project and not competitive with the import alternative. Smaller perimeters with less land-leveling cost per unit of area could probably sharply reduce costs.

The choice-of-technology issue in rice is, however, not simply a question of choice between technologies X and Y. In each type of technology there is a substantial proportion of farmers who produce rice competitively (compared with equivalent import prices) and others who do not. Mean values can provide only a rough guide. A key issue is to identify, through efficient monitoring, the technical constraints that keep certain

farmers at the upper end of the distribution of unit cost of production, and thereby find ways to move these costs downward. Again, this means rejecting the narrow approach of focusing on yield levels per unit of land instead of focusing on returns per unit of labor.

Under erratic, unfavorable rainfed conditions, owners of small, irrigated rice plots with substantial upland crop enterprises are caught up in a difficult decisionmaking process for farm production because of increased competition for their scarce labor resources. With labor productivity-increasing measures in upland crops, this competition is likely to be further intensified in a situation of land abundance, as noted above. The climatic difficulties of wet weather in July-August and cold weather in November-January require, for profitable double-cropping of irrigated rice, a high degree of timeliness in the management functions of farmers and schemes for accurate sequencing of the cropping program, and organization and mobilization of production support services and inputs. The difficulties in these management functions are compounded by complex crop-mix patterns. Although these accentuating forces impinge directly on the wet-season irrigated crop more than on the dry-season crop, their effects are transmitted through the crop-sequencing process into the dry-season crop.

Protection and Enhancement of Women's Productive Role in Agriculture

The Jahally-Pacharr project has a strong focus on protecting and enhancing women's role in crop production. Despite considerable efforts by program planners to maintain women's access to the new rice technologies, women farmers ended up mainly with access to the lower-level, lower-yielding technologies. The men, on the other hand, took control of the highest-yielding rice technology, which consequently increased their returns to labor much more than was possible for the women. The increased food security now provided by the new technology did not exist before in this location. Growing the new rice crop required a shift of male labor resources under the authority of compound heads from traditional *maruo* production in upland fields to the new rice fields. It was thus perhaps inevitable that the rice ended up under the control of compound heads. In view of this experience, how can women's participation in technological change be improved? Briefly, the lessons are these:

1. The selection of a "women's crop" for promotion does not guarantee that the new form of crop production will benefit women more than men.

2. Project managers cannot guarantee the protection of traditional production arrangements while at the same time fundamentally changing the nature of that production.

3. Women are much more involved in independent cash crop production (cotton, groundnuts) than has generally been acknowledged. Yet their access to means of increasing their labor productivity (fertilizer, tools) in these crops was less than men's. This finding indicates that there is a potential for women to be included in the mainstream of the agricultural development process through a program of upland cash crop promotion as well as the improvement of swamp rice, taking account of women's labor constraints.

Women's interest in the new rice technologies and in upland crops would be safeguarded and enhanced by increased access of women to credit for the short-term financing of productive inputs. It is not just fertilizer and seed acquisition that is required, but transport, on-field threshing machines, village-based milling machines, bridging of short-term labor bottlenecks by labor hiring, and so on. Village-specific women's groups that exist traditionally in many of the communities could form the basis for cooperative organs through which loan security might be provided.

The suggested move away from promoting a single crop (rice) to promoting improved labor productivity in rice and in upland crops together would further reduce the pressure for competition between men and women in rice production and thus permit women to capture a larger share of the benefits accruing from technological change.

Allocation Policies for Irrigated Land: A Food-Security Perspective

Complex land tenure issues arise when highly valued irrigated land is developed in an area where there is abundant (low-value) land supply for rainfed agriculture. Who should get access to the new land, to what extent, for how long, and under what conditions? An auction approach to land distribution cannot be recommended on equity grounds because the poor do not have effective access to capital markets. Any rationing criteria have to be complex. Original rights to land taken over by the scheme and household labor resources are key factors.

The distribution of new land among large numbers of villages and among many compounds within each village had a favorable effect in the Jahally-Pacharr case. The benefits of the dry-season crop for reduced calorie deficiency during the wet (hungry) season were well spread out among the local communities. There are no indications that potential returns to scale were lost by this approach. Traditional acquaintance with irrigated agriculture is not necessarily a recommended criterion for land distribution, since farmers from villages that had little experience in rice production obtained the highest yields in this project by carefully following production recommendations.

The development of small-scale irrigation schemes that provide farmers with a less drought-affected, additional income source in the form of food has obvious advantages for food security. Against the background of the very low savings rates of the rural poor, this food-security effect is particularly relevant in this West African environment where rural capital markets are thin.

With large year-to-year fluctuations in rainfall, labor productivity in rainfed agriculture fluctuates similarly, and this instability is transmitted to irrigated rice schemes through the labor supply to such schemes. Years of good rainfall are, therefore, bad for yields in irrigated rice, as labor is not forthcoming so much as in years of drought. This is reflected by the drop in yields in fully water-controlled rice from 6.6 to 5.2 tons from the drought year 1984 to the year 1985, which had reasonably good rainfall. The fixed cost per unit of output in irrigated rice is thus higher in years of good rainfall. Yet, as long as crop price levels and ratios are not much distorted, the resulting yield fluctuations due to the shifting of labor between crops are a consequence of efficient reallocation of resources.

A focus on stable yields in schemes under those circumstances would be misleading. Schemes have to live and cope with the phenomenon of fluctuations in this region. With a wider distribution of land in a scheme—that is, smaller plots per household—the transmitted fluctuation “problem” increases, as the income from irrigated rice becomes more marginal for each household. Yet the food-security benefit at the household level is certainly increased with a wider distribution. This food-insurance function of irrigated rice at locations where other means for improved household-level food security are scarce argues for broad access of villages and for small allocations of irrigated land per household. Choice of varieties (that is, fast-maturing ones) may ease the fluctuation problem to some extent.

Income of the Poor and Consumption Linkages

This study has stressed that the substantial differences in per capita income between households in rural Gambia are long-standing. A targeting of productive resources and employment toward the poor is thus called for in programs aimed at nutritional improvement through economic development.

Additional income generated by the poorer households translated into more food-energy consumption and more nutritional improvement than in the rest of the population. Calorie deficiency is largely confined to the lowest 25 percent on the income scale. These 25 percent are forced to adjust their calorie consumption downward in the hungry season, while the rest of the population does not. In principle, this suggests that emergency food aid programs could be targeted at much smaller groups in the rural areas than is frequently assumed in The Gambia. Administrative targeting, however, is not easy in this environment. It requires considerable knowledge about the specific communities. Local administrative capacities are too limited for such tasks.

Low income in this land-abundant setting is caused mainly by low labor productivity in agriculture, which in turn is a result of inability to acquire productivity-enhancing inputs and tools. Any additional income, derived from traditional cash crops (such as cotton and groundnuts), staple foods, or nonagricultural income and transfers (remittances), is expended equally on food and nonfood consumption, regardless of the income source. Whether the income is in the form of cash or food does not make any difference to changes in the food-energy consumption of households. This suggests that agriculture-based programs for poverty alleviation and nutritional improvement in this area do not need to be limited to food-crop promotion, but need to focus on the most effective way of promoting income growth among the poor, which may well be through technological change in food production.

Reinforcing Effects of Development on Nutritional Improvement

Increased income translating into food consumption was found to be a powerful force for the nutritional improvement of malnourished children in The Gambia. However, the complex web of nutrition and health interactions suggests that the improvement of health should be a direct target linked with raising consumption levels through income. Rural health services need to be upgraded and moved closer to areas of demand/need in order to enhance the favorable income-consumption linkages for nutritional improvement. A practical aspect of this is unclean village water supplies (found to be a significant factor in nutritional deterioration), which should be a priority focus of complementary programs of rural development. The burden on mothers' time for child care in the wet season, increasingly strained by extra work in rice, requires a creative, village-based response. Child-specific interventions, parallel with agricultural development, should focus on children of low birth weight and the factors causing a nutritional deterioration of children aged one to three years. This is where the key problem of child malnutrition lies.

As confirmed in this study, agricultural programs and policy can directly affect the symptoms and patterns of malnutrition. The positive effects of agricultural development can, however, be strengthened by effective public health services. These services should be coordinated in a strong national system that is designed to tackle, as a priority, the preventative and curative needs of the rural poor. A project-by-project approach to health delivery can easily lead to inefficiency and injustice.

APPENDIX:

SAMPLE SELECTION AND SURVEY DESIGN

Sample Selection

In the project area itself, eight villages were identified in a two-stage random sample selection. The Jahally-Pacharr Project Management Unit provided a complete list of project villages with information about village size and the project rice land allocated to each village. Eight villages were chosen from this list by stratified random sample. Stratification criteria were (1) size of the village (that is, number of households), (2) distance from the Jahally and Pacharr swamps, and (3) ethnic group. The profile of the selected villages (Table 57) shows the representation of both large and small villages around the two project sites (Jahally and Pacharr swamps), of ethnic groups, and of different degrees of involvement in the project.

Two additional villages located outside of the project area were chosen randomly from other rice-growing villages to broaden the variability of observations and to represent the situation in the Jahally-Pacharr area before the project started. Both villages are involved in traditional swamp rice production or older pump-irrigated rice schemes or both. Choosing only two villages outside the project area was considered sufficient, as village and household participation within the project area already showed great variability.³³

In the second stage of sample selection, a baseline survey of all households in the selected villages was carried out to provide basic information about household demography and project involvement. Roughly three out of four households in each village were chosen randomly from this survey for interviewing. As described in detail in Chapter 3, the "households" in the study area can be very large units (compounds), frequently with 40-80 people. Averages at village level range between 7.9 and 16.5 persons in the sample villages (Table 57). The random draw of households at village level mentioned above refers to compounds. A total of 168 compounds was drawn into the sample. However, in some of the Wolof, Mandinka, and Serahuli compounds, most of which are very large, the compounds were subdivided into subunits of decisionmaking and management of consumption and production affairs. In special interview sessions with female and male compound leaders, the compound structures were evaluated and, where appropriate, compound subdivisions were taken into account. In these cases when compounds were subdivided, all units were maintained in the survey to permit flexible aggregations if required for specific analytical questions. The subdivision of the compounds resulted in a total of 214 household units (in the case of Mandinka villages, usually referred to as *sinkiras*).

The study sample compounds from the eight villages in the project represent about 10 percent of the total compounds participating in the project and also about 10 percent of those compounds involved in the fully water-controlled rice production. Fifty-two percent of the sample compounds have an average field size of pump-irrigated rice exceeding 0.25 hectare (equivalent to one-half of a plot). The equivalent percentage

³³ Certainly, a larger and more regionally distributed sample is desirable. Logistical constraints prohibited that in the 1985/86 survey, but in a follow-up survey in 1987/88 the sample was extended to three villages on the north bank of the Gambia River.

Table 57—Profile of sample villages and sample compounds, 1985/86

Village	Number of Compounds in Village	Number of Compounds Selected for Survey	Main Ethnic Group	Distance from Project Land (kilometers)	Average Size of Sample Compounds (persons)	Area of Fully Water-Controlled Project Land		Coefficient of Variation
						Per Compound	(hectares)	
Njoben	50	28	Wolof	11	15.3	0.16	0.16	0.70
Pacharr	59	33	Mandinka	4	16.5	0.40	0.40	0.78
Dasilameh	50	36	Mandinka	4	9.3	0.63	0.63	0.55
Sinchou Abdou	15	11	Fula	4	8.8	0.22	0.22	0.86
Kussalang	18	13	Fula	11	7.9	...	...	...
Sare Samba Sumali	16	10	Fula	8	9.5	0.16	0.16	0.96
Sare Bala	7	7	Fula	6	8.4	0.14	0.14	0.11
Sukurr	10	8	Serahuli	3	16.1	0.56	0.56	0.32
Teteng Fara	12	1-1	Mandinka	...	9.8	...	...	...
Touba N'ding	12	11	Mandinka	...	8.1	...	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

figure for households in the total project area is 45 percent. The average field size (rice) of the sample farmer is slightly lower (0.56 hectare) than in the whole population (0.69 hectare). Some of the sample villages (those in the Pacharr swamp area) also have access to a considerable amount of partly water-controlled (tidal-irrigated) land in the project.

Averages of key indicators show that the selected sample comes close to being representative of the study area as a whole (Table 58).

Sample Design and Data Collection

The household survey was executed during the rainy season of 1985 (August-October) and during the dry season of 1986 (January-March). The data collection was carried out by a carefully trained enumerator team, closely supervised by IFPRI staff on a daily basis. IFPRI staff and enumerators lived in the villages throughout the surveys. Half of the enumerator team were women, who generally interviewed women.

Data collection was tailored to examine the complex production and food consumption situations in the households. Considerable time was invested in designing and pretesting questionnaires on production, consumption, and nutrition that were appropriate to the local conditions and the specific research task. The questionnaires were precoded for direct data entry after completion. The set of questionnaires for each survey round consisted of the following:

1. A *demographic questionnaire*, which identified persons belonging to the household and its demographic characteristics (family relationships, household organization) and those responsible for crop production or owning livestock or both. This questionnaire formed the basis for all other questionnaires by identifying the appropriate respondents for specific issues, such as head cooks of consumption units (for consumption survey), all mothers with children under 10 years of age (for nutrition and health survey), all adults (for expenditure and nonagricultural income survey), all farmers (for agricultural production and marketing survey), and compound heads (for storage survey).

Table 58—Project land farmed, by compounds and area

Compounds/Area	Total Project Area	Sample Compounds in Project Area with Access to Project Land
Number of compounds	1,414	152
Fully water-controlled area		
in project (hectares)	548.00	54.50
Area per compound (hectares)	0.39	0.36
Villages with high involvement in project ^a		
Number of compounds ^b	642 (45)	79 (52)
Area per compound (hectares)	0.69	0.56
Villages with low involvement in project ^a		
Number of compounds ^b	772 (55)	72 (48)
Area per compound (hectares)	0.13	0.14

Sources: Jahally-Pacharr records and 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a High = more than 0.25 hectare per compound of fully water-controlled land; low = less than 0.25 hectare per compound of fully water-controlled land.

^b Numbers in parentheses are percentages.

Because of the complexity of intrahousehold organization, much of the information was gathered on an individual-by-individual basis and later aggregated to the appropriate unit of observation (for example, individual snack foods of members of a cooking unit).

2. The *food consumption questionnaire*, which covered day-by-day, weekly, once-a-season, and more long-term recalls of food acquisition and consumption, plus eating and cooking arrangements.

3. The *health and nutrition questionnaire*, which was applied to all mothers or caretakers of children under 10 and included specific demographic, child-care, and child-feeding information on a child-by-child basis; morbidity recalls for children and mothers/caretakers; mortality information; mothers' time allocation (when working away from compound); and anthropometric measurements of children and mothers recorded in each round (weight and height).

4. The *expenditure and nonagricultural income questionnaire*, which applied to all relevant adults and included a week's snack food survey; a week's survey of frequent nonfood purchases; a long-term (seasonal) survey on large expenditures, using a list of 60 expenditure items or groups of expenses; nonfarm income in cash and in kind; and remittances.

5. The *agricultural questionnaire*, which applied to all men and women farmers and examined field-by-field data on inputs, production, use of crops for the relevant seasons, livestock, and vegetables. Institutional arrangements of production (communal, individual) were assessed. Labor inputs were enumerated on a field-by-field and operation basis by sex. Land use was measured in a subsample of 10 percent of fields to cross-check with recall information. Ethnic group-specific and compound-specific units of volume measures were used for quantities of output produced and marketed or otherwise disposed of. Prices for all major transactions of outputs and inputs during the recall periods were similarly measured in the units most convenient to households.

6. The *storage questionnaire*, which was carried out with the household head and other relevant adults, involved quantifying current stock levels by crop and by storage responsibility (individual and communal storage).

The complex surveys required considerable time and effort by the enumerator staff. A key to successful completion was the excellent rapport developed in the villages by the survey supervisors. For example, some of the senior staff were allocated fields by village headmen, and they organized their own upland field crop production during the survey. Few households dropped out of the survey.

In-Depth Study

Because of the diversity of household organization in this setting, an in-depth study (Webb 1989) on decisionmaking and resource control inside the household unit was added to the structured main survey. This more detailed analysis focused on a 10 percent subsample of the large sample households. The in-depth study provided micro-level data necessary for an assessment of the distributional effects of technological change and commercialization within the complex social networks that make up the Gambian household. Through closely supervised questionnaire surveys, participant observation, and a detailed accounting of labor flows, an attempt was made to identify the individuals most affected by the introduction of new agricultural technology.³⁴ This intrahousehold information was fed into the large-scale survey, permitting insights to be followed up in the field.

³⁴ For a fuller account of this in-depth survey's design, implementation, and results, refer to Webb (1989).

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